The drawings design realized by parametric computer systems

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IMProVe 2011 International Conference originates as the 5th Joint Conference of *ADM* (the Italian Associazione Nazionale Disegno di Macchine) and *INGEGRAF* (Asociación Española de Ingeniería Gráfica) and has been organized by the Design Tools and Methods in Industrial Engineering Lab. and the Drafting and Representation Lab., both belonging to the DAUR Dept. of University of Padova. From this edition, the Conference is also supported by *A.I.P. PRIMECA* (Ateliers Inter-établissements de Productique - Pôles de Ressources Informatiques pour la MECAnique) and *IJIDeM* (International Journal on Interactive Design and Manufacturing). This event has been proposed as a significant opportunity for discussing on product innovation issues from interdisciplinary point of views, to promote new workgroups and international networks in both engineering and architecture areas.
As can be recognized by these proceedings, *IMProVe 2011* has proven to be a forum of experts in engineering and architecture design from academia and industry, committed to share the different experiences, skills and ideas and to, jointly, identify new working hypothesis for the design of innovative products.
The quality of the contributions was assured by a double blind review under the supervision of the Scientific Committee, as explained hereafter. I want to personally thank every member of the Scientific Committee and of the Reviewer Committee for the strong commitment and expertise demonstrated in this sensitive and very important task.
Finally, I hope that this event could be one step towards a stronger and fruitful cooperation among ADM, INGEGRAF and AIP-PRIMECA associations, and also open new links with the innovative experiences in the fields of industrial design and architecture.

Gianmaria Concheri

IMProVe 2011 Chair

IMProVe 2011 Scientific Committee note

The IMProVE 2011 Conference has reached a quite large audience of researchers interested to its topics, and 223 submission have been gathered by the OpenConf CMS, mainly from Europe.

The review process has been possible with the work of the Scientific Committee, to which other 43 colleagues, mainly Italian and Spanish, have given their cooperation to guarantee at least two assessments per paper. Each reviewer has assessed 5 papers (average value) with a variance of ±3 papers. The double blind review process has selected 156 papers (70%), that have been subdivided between 98 for oral presentation (63%) and 58 for the poster session (37%).

Accepted for oral presentation were the papers that reached a score greater than 4/6 (being 6 the greatest value used by the CSM). The paper assessed by a score lower than 4/6 was selected for poster session, even if in some (few) cases the improvement received by the paper, on the basis of reviewer comments, brought it up to oral presentation. Fortunately in few cases (lower than 10) was necessary to assign the assessment to a third reviewer, and this allowed the Scientific Committee to solve the conflict emerged. The papers with scores lower than 2/6 were rejected by S.C. or withdrawn by the authors.

Submitted abstracts: 223
Accepted papers: 156
Papers rejected or withdrawn after the revision process: 67
Accepted papers origin:

- Argentina 1
- China 1
- Colombia 1
- France 13
- Hong Kong 2
- India 1
- USA 1
- Italy 82
- Poland 1
- Spain 61
- Tunisia 2

(The above list cites only the corresponding Authors. The Author nationalities include more countries e.g. UK, NZ, etc.).

Number of reviewers: 82:

- Italy 50
- Spain 18
- France 12
- UK 1
- USA 1

On behalf of the Scientific Committee, I would like to thank all people who spent part of their time to give a real improvement to the papers that will be presented at the Conference.

A further step will remain to do. During oral sessions the quality and the interest of the presentations will be also assessed. On the basis of this latter and the previous scores, a very reduced number of papers will be selected by Scientific Committee for publication on the Int. J. on Interactive Design and Manufacturing.

Good luck and thanks again

Sergio Rizzuti

Scientific Committee Coordinator

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The drawings design realized by parametric computer systems

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Abstract

The parametric computer graphic systems adoption, meant as dialogue and interaction tool among the various operators of the building construction, is based (since the first phases of the preliminary project) on the management of a unique database related to the various actors of the design process. This leads to an able to interact with the various actors of the project according to a deductive logic of it. The virtual model performs both to geometric and to semantic level, operating to interact both the formal knowledge and the technological one. At this regards, great opportunity is therefore given by the chance to build, through the Drawing, a very complex model, susceptible of investigations that go further the cognitive searching traditionally connected to representation's field.
This particular feature implies that computer drawing has not only to be considered the communication language but the opportunity and the means to search for the truth and the overall accuracy of the design idea. This is basically the weld between "what" and "how": and the distinction is not between draw (understood as thing's physiognomy's developer) and project (meant as forecasting of the thing itself), but the draw becomes at the same time a trial and an instrument.
The paper includes some professional experiences, aiming to explain the adoption and the implementation of BIM (Building Infomration Modeling) methodology, developed through the cooperation between the Building Service of the Politecnico di Torino and the Department of Building Engineering and Territorial Systems (DISET) of the same university. Other case studies are developed by the same authors of the paper through the collaboration between some Italian professionals and DISET researchers.

1 Digital drawing for decision-making *(G. Garzino)*

The desire to base the construction of a building on rigorous control of the parameters that govern it, belong to the "substance of things hoped for", to paraphrase Edoardo Persico [1], since the dawn of western architectural thought and it has accompanied architects on a thousand year journey from Callimachus to Le Corbusier, whose "modulor" represents the product of knowledge of arithmetic (from irrational numbers to the Fibonacci series), geometry (the constancy of the proportional average is based on Euclid's two theorems of a rectangular triangle), ergonomics and anthropometrics. More generally around the 1970s, a denial of project design as a method of governing modernity occurred and the conditions were therefore created, in a structural manner, given the remarkable insight of some architects, for the entrance onto the drawing scene of new disciplines such as computer science, already involved in that period in other sectors of the world of production. Written documents and systematic methodologies were preferred to technical drawings. A desire was pursued to apply the methods that science had devised for complex systems, already applied in other fields, also to building. Architects were given the task of formulating problems: questions were posed in terms of basic requirements and needs, the same as those connected with reciprocal relationships in everyday life. Traditional practice was incapable of considering and at the same time processing, according to the new systematic approach of the knowledge process, all the elements of a problem. On the other

hand, the need to reach a summary result, led to the belief that an effective means could only be deployed with the support of combinatory analysis, which of course was made possible by computers. As a consequence mathematical algorithms and computer processing was employed to explore possible relationships from which to extrapolate the most appropriate design solution.

A significant step ahead was taken at the beginning of the 1980s when the concept of "expert systems" was introduced, which employ an interrogation process to generate suggestions and indications of how to solve determined problems.

The true quantum leap ahead in quality arrived with the migration to hierarchically structured software programmes which would run on personal computers [2]. These hierarchical structures made it possible to establish dynamic relationships between data that described a design in three dimensions, thereby making it possible to simultaneously address as a single entity what until then had been separated: it was no longer analysis or just geometry or just semantics, but spatial and construction analysis at the same time. A new method of computer aided design was thereby investigated, that of object based parametric design. The use of hierarchically structured software brought with it the representation of a building design in terms of a number of parts which, depending on their level in the hierarchy, assumed the role of complex construction elements or modifiable building components[1]. The use of computers is in fact useful not so much for solving the problems of complexity, closely connected with the conception stage of establishing shapes and form, so much as a support for modelling, making interactive design possible, where formal and distributive investigation is flanked by verifications in physical, technical, structural and financial terms and so on. The issue is therefore that of construction, with the drawing of a complex model subject to investigations which go much further than searches for information traditionally connected with the world of drawing. Compliance and semantic factors sit side-by-side in parametric design and in this case these specifics enable design to escape its static condition to assume the dynamic character of its interactive nature as a graphic representation of a model.

Interactive computer models provide opportunities that were unimaginable with physical models and they constitute a combination of a three dimensional plastic model or its digital equivalent (except for some important differences) and a prototype model, once very common among producers in disciplines such as building construction and hydraulics. They conserve the continuous development and propensity to change of a plastic model and at the same time they possess the semantic richness and the quantitative feasibility of a prototype. As opposed to what might be imagined from a first and superficial analysis which looks only at the most obviously attractive aspects such as rendering, information technology brings a strong characterisation in terms of the communicative symbols of a building design. It therefore brings not just an uncommon search for urban icons and formal experimentation, but also relations with the academic world and multi-disciplinary tendencies. Techniques using diagrams are therefore extremely important in the drive towards performance to the point where they become a representation of the behaviour of a building design, a key to interpreting what is described at the input stage with computerised drawing. A diagram is in fact a sort of "abstract machine" which sits alongside traditional geometrical and reproduction type representations [3], the effectiveness of which lies in its interdisciplinary nature: *it is able to act as mediator between different and interrelated quantities, with explanatory functions and as a sort of graphical short cut for the representation of more or less complex phenomena*. [4] *The diagram is not a metaphor or paradigm […]. The meanings of diagrams are not fixed. The diagrammatic machine is not representational. It does not represent an existing object or situation, but it is instrumental in the production of new ones [5].* When interrogated, electronic representation responds with information that is no longer rigid, but which dialogues with data that can change with changes in input conditions: this behaviour not only occurs in the singularity of each parameter but rather in the changed relations of the whole. A distinction is therefore made, spoken of by Bernard Hamburger, between traditional and nominal heuristic design [6].[2] In reality the latter can be more properly referred to as computerised heuristic design and is characterised by a team environment in which the whole design group participates, bringing a sort of network into play, in contrast with traditional practice, linked to an individual and personal environment.

With things as such, two different approaches appear from a methodological viewpoint. The first method is that which has been outlined mostly until today and it is that of a simulation model which takes shape from the graphics input and draws from a hierarchically structured data bank of three dimensional data. Parametric design is normally conducted with basic software and then a series of specialist software applications interact with that software by means of data interoperability to simulate and verify the model thus constructed. With exception made for the necessary substantial considerations concerning the central role of the information, the traditional design approach, where the design of the morphology of a building object remains the starting point, is maintained by following this procedure. It is possible to further distinguish, within this approach, between a method of *ex post* support verification and one where the possible idea gradually takes form and is continuously refined with interactive verifications which follow. A second type of approach is also possible, however, where the starting conditions do not consist of a possible idea expressed at the initial stage with a sketch on paper, but of a series of relations of a topological nature expressed in the form of a diagram. The model does not simulate to then verify, but becomes itself a generator of design metaphors[3]. Consider for example some of the works by Makoto Sei Watanabe, such as the Lidabashi underground station in Tokyo (2000) where the formal impact of the structures in elevation originate outside the ground from a series of

[1] *A distinction must be made between primitives, instances (examples), objects and classes. As opposed to what happens in CAAD environments, where primitives are simply three dimensional elements corresponding to a model, in a hierarchical structure, the term primitive refers to the basic constituents of a building: bricks, glass sheets, door and window frames, floor beams, etc. Each primitive is defined differently from the others and is given a specific name, so that it can be identified accurately. Primitives can be combined with each other to create complex elements: construction elements termed objects. In this case the primitives are transformed to become examples, i.e. recurring symbols. The symbols can be duplicated and manipulated parametrically, while the relative characteristics of the constituents can only be modified at the level of the primitives. Furthermore, when an object (e.g. a window object) is inserted in a hierarchically more complex object (e.g. a first floor object), that object falls to the level of an example, i.e. a lower level and the relative spatial relations (e.g. those between the frame and the glass) which have fallen to the level of a primitive can be modified.*
This procedure constitutes the true strength of hierarchical structures. Take for example the case of changing the thicknesses of the window frames of a building. In this case it is not necessary to change the individual windows one by one because the modification can be made at the level of the frames initially employed as primitives and it can be performed with one single operation. What is more, the operation can be repeated many times to explore different alternatives. In fact the graphics information relating to the thickness of a window frame can be read directly by a spreadsheet and parameters such as cost, permeability to the air and any relationship at all that is specified can be investigated. The ability to make instant changes based on the principle of automatic propagation of the modifications made to a primitive is termed instantiation, and it gives simulation both at a geometric and a semantic level. (Many of the considerations and examples given in this note have been taken from: Saggio Antonino, "Introduzione alla rivoluzione informatica in architettura", op. cit. pp. 86-87).

[2] *This concept is taken from Converso S., Precisione digitale e processo condiviso in "Esempi di Architettura", year I, n. 3/2007, pp. 59.*

[3] *A central role is played in this respect by the research conducted by Peter Eisenman together with those of UN Studio. Cf. P. Eisenman, Diagram Diaries, Thames & Hdson, London, 1999, and cf. A. Marotta, Ben Van Berkel. La prospettiva rovesciata di UN Studio, Testo & Immagine, Turin, 2003.*

iterations with a specially developed software programme, designed to organise a ramification of elements which creep into the available space, just like vine shoots in nature. The ramification proposed by the software at the beginning is then further processed to summarise its compatibility with constraints of a functional, distributive and structural nature. The design for the façade for the station for the Kashiwanoha (2004-05) campus was studied in the same way, by analysing the interaction between external projected space and the movement of air caused by the trains[4]. This approach is then flanked by yet a further possibility, offered by the exploration of a territory, the confines of which expand each time it is investigated. This occurs with software which enters the very fibres of new buildings through home automation, or domotics as it is called, and the control of various parameters (opacity of the windows, the orientation of the sunbreakers, etc.). New techniques for building and the subsequent management of them therefore unfold whereby not only the design but also the buildings themselves become interactive and alive, reacting to changes in flows, stimuli and desires [7].

Nevertheless, because of its interactive nature a hierarchically structured software application becomes a live object, completely different from anything seen before (even with regard to “types” which, although they allow for different options, are constants by nature), designed not so much for orientation as for scientific analysis. The big change imposed by the “computer revolution” does in fact ensure that the categories by which thought was previously structured no longer correspond to the reality. As opposed to the industrial age, types, standards, zoning and so forth are no longer central, having been replaced by the specific which opens up to the multiple or, to put it in knowledge terms, the hypotheses have replaced the theories. Reality is unveiled in the form of relationships and mathematical processes. And interactivity, which privileges the figure of the subject with respect to the object, which is characterised by the continuous reconfiguration of space and which puts the “narration” at the centre of things defined as a story to be told before the presumed cause and effect relationship advanced by the proposed design, really does seem to be the correct way to proceed in a world where the linear relationship based on the principles of cause and effect no longer holds. The issue is therefore that of knowledgeably governing a system of given relationships. Just as renaissance architecture was transformed to become humanisable, as perspective in the age of humanism contributed to the creation of consistent and specific systems (leading to the abandonment of polylobed systems) and as buildings in the functionalist period were structured to be industrialised (serial, abstract and mechanical)[8], the stimulating issue that springs from these considerations is therefore that of thinking whether a new season can really emerge: that of architecture as the child of a decision-making model. After two centuries, those of nineteenth and twentieth century industrialisation, in which the geometric, functional-compositional and formal approach to building design was organised mainly on the basis of the production of the construction, a new era has perhaps arrived. It is an era in which the nature of buildings will be based partly on the design process and therefore on the new system of design proposed by computers, that which is implemented with the creation of an interactive graphics model: a decision-making model.

2 BIM technology as a collector of heterogeneous data *(M. Lo Turco)*

At present professional practice requires more and more specific skills and extremely tight deadlines; at the same time the historical period reveals a trend to orient software technologies towards a more conscious and structured use in a continuous research - sometimes exhausting, other times more productive – for procedural strategies using shared platforms.

At the same time, the market is changing by offering a large number of applications created to solve different matters. The same term “parameter” is characterized according to the application context: if in mathematics is defined as an arbitrary mathematical constant, referred to systems, formulas and equations, in design field it may take different shades: unlike pure parametric software, the object software have more relationships with the architectural design, where the internal libraries available are shared out by types of building elements.

In other scenarios, the same term means the control of a large number of variables (not only the geometric relationships) that allow managing a particular process (design, construction, management,). In computing, "*the parameter is a value that a function expects to receive in order to perform its work*"[9]. In other words, the function, the software and the operating system expect (*values*) and want to know (*what to do*) because the computer programmer has explicitly provided that information to be taken, so that it is expected to pass parameters. In last years, in architecture, engineering and construction industry it has been introduced a substantial change, both in design methods, representation and project documentation and in construction technology. The building process has become a very complex series of actions; each of them consists on a large amount of information coming from different fields [10].

With the increasing information and the resulting complexity of the process, architects and engineers have come up against new realities of design, more difficult to manage. The request for more specific documentation, detailed analysis, regarding to the different topics of design, (from the structural and energy ones up to the cost evaluation), has a feedback on time planning: the coordination between all the actors involved, the management of various skills and their integration into a single process, is going to push the professionals in the searching of a tool of suitable support for their work. At this regard, the continuous progress of research, especially in the field of energy, according to experimentation of innovative construction details designed to reduce energy consumption, have led to a consistent increase in the time of conception, design costs and construction. The introduction of BIM implies a radical change regarding to the techniques, methodologies and tools of design and, consequently, the role played by individual professionals: it was said that the center of the whole process is the virtual building model itself, from which have been extracted different representations of the

[4] *Makoto Sei Watanabe then designed a series of software applications with specific functions: Wind-god-city, addressed the relationship between ventilation and exposure to the sun; On demand city considers the relationship between functional location and changes in distances between activities; City on the hills the relationship between settlements and orography; Generated city block the relationship between road intersections and routes.*

building and all the information needed to manage the various design phases. Each of the traditional drawing representations are not simple geometric entities related to each other by means of spatial coordinates and simple geometric rules, but they are interactive representations of the model to which they belong.
This allows designers and all those involved in the design process, (including contractors) [11], to share project information in a simple and transparent way. The aim of BIM technology is to get an overview of the design and of the building itself setting all the information linked to performance, qualitative or quantitative ones, inside the virtual model. So, while the first Computer Aided Design allowed to have additional information on the performance of the building through drawing annotations, a BIM model contains the information and key features to understand the model as a whole: each architectural element that constitutes the BIM model is characterized by performance schedule of materials properties, energy information, lighting and acoustic analysis, thermal - physical, economic evaluations..., which identify and characterize the building [12]. Doing that, it is possible to eliminate the usual problem of re-edit the drawings when it is needed to make specific analysis: normally, using CAD tools, the different analysis related to the current building process are normally connected to the final stages of decision making, leading to further delays due to the need to make the changes required only when the building definition presents a developed stage. Nowadays, using BIM processes, the detailed analysis, consistent with the different topics required for the design of the building components, can and must be done during the early stages of design, together with the choices made by professionals, in order to give back the decision-making process more consistent and clear.
Leaving aside the undoubted advantages of BIM tools in the later stages of the design, the chapter aims to present the added value given by recent parametric software for preliminary studies regarding to some Functional Economic Analysis. The following paragraphs show some case studies developed through the cooperation between the Building Service of the Politecnico di Torino and the Department of Building Engineering and Territorial Systems (DISET) of the same university.

2.1 BIM processes developed for the Building Service of the Politecnico di Torino.

In last times, a research group inside DISET Department, through the work of some fellowship researcher, has begun to cooperate to the new design processes involving new areas of Politecnico di Torino. The versatility of the figures involved, often divided between teaching and research, has made possible to transfer some knowledge about new parametric tools within the internal structure of the Building Service, responsible both for new interventions, and for all the management procedures that concern the University. The works most frequently requested are constituted by several Functional Economic Analysis (FEA) that allow making some resolution on certain design choices, through integrated approaches: on the one hand evaluations of design typologies, on the other allowing a more immediate economic evaluation. The parametric software used is Autodesk Revit Architecture.

2.2 Functional Economic Analysis (FEA)

Recently, the current regulation on Public Works has indicated, through the d.P.R. n. 207/2010, (Regulations implementing the Decree n.163/2006 – Codice dei Contratti) the contents for the various design phases. Article 14 refers to the Functional Economic Analysis, specifying in detail the contents, partially returned in the following list:
- a description of the prior assessment of territory sustainability of the intervention, and the requirements of the designing building, the feature connection with the existing context, with a particular attention to verify the historical, archaeological, territorial constraints related to the areas affected by the intervention. This lead to identify appropriate measures to safeguard the cultural and territorial values;
- the integrated analysis of different design alternatives, regarding to the functional, technical, managerial, economic and financial matters.

The bylaw of January 14th 2009 specifies that, in spite of the Codice dei Contratti and d.P.R. 554/1999 do not provide an adequate framework for FEA, both for contents and for processing, it is considered that the FEA document must balance two needs: firstly, it allows the acquisition of the due prior authorizations by virtue of the completeness and reliability of its content; secondly it has to hold the right place for competitors creativity during the subsequent phases. In particular, the FEA should enable the definition of the cost intervention, drawn from a quantities take-off or on the basis of parametric costs derived from similar interventions.
The right draft of FEA containing technical, designing, legal, administrative (including the planning ones) and financial matters, also aims to enable the drafting of preliminary project, minimizing the risk of changes. This is the case of some projects showed below, in which the parametric tools ensures very quickly a true foreshadowing of the final result. The following proposed solutions are the result of a methodological process that provides the control of phases and design options linked to economic factors: these are estimated, as suggested in the regulation, through parametric construction prices obtained by analogy to similar interventions.

2.3 FEA for Politecnico di Torino: Pavillons 3 and 3B of Nervi's Torino Esposizioni

Below, there are some actions proposed for the requalification of certain areas currently unused or under transformation: the authors of the forthcoming proposals have worked closely with several divisions of Comune di Torino, in such a way as to transpose some directives for changing or specifying the city planning tools provided within the Piano Regolatore Generale Comunale (PRGC).

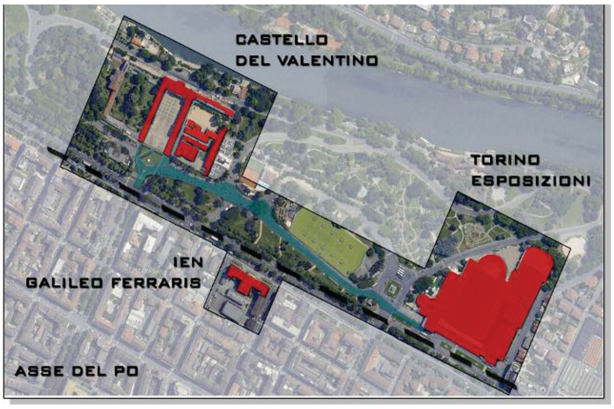


Fig. 1 Urban Plan

The following project consisted on the possibility of re-functioning part of the famous building called Nervi's Torino Esposizioni, in order to achieve along the Po river a new educational center of the Politecnico di Torino, through a new longitudinal axis together with Castello del Valentino and the IEN area.

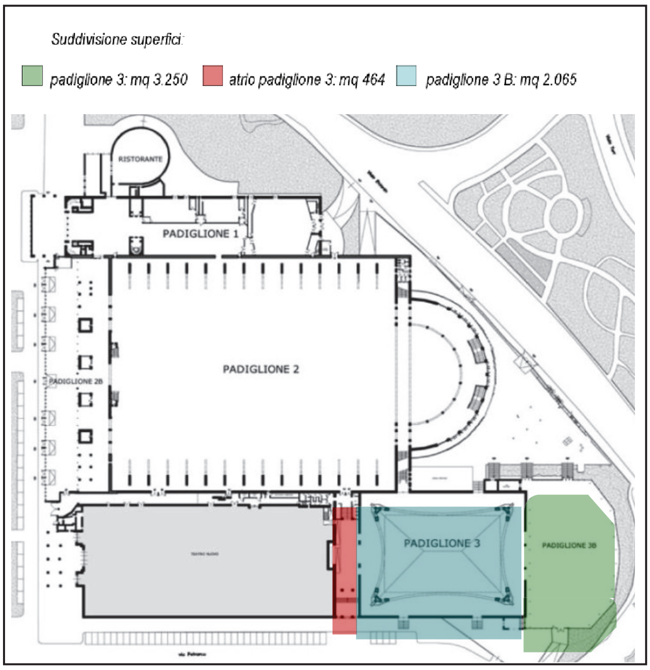


Fig. 2 Internal plan

The hypotheses proposed foresee the conversion of the Pavilion 3 and 3B to classrooms and labs, through the construction inside the internal volume of these large spaces. Firstly, it was needed to be established the cost intervention parameters and the evaluation of square meters actually achievable within these areas to great heights.

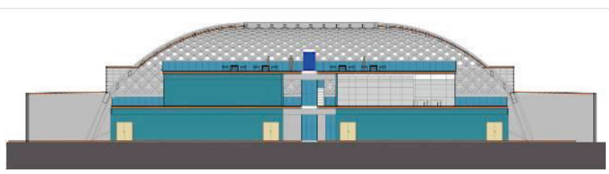


Fig. 3 Longitudinal section

The outcome of this study has determined that the intervention would be hardly sustainable: this was achieved through the interrelation of data between virtual three-dimensional model, the estimated quantities take off and the costs evaluation (parametric value for square meter), at this regard the FEA should be able to turn the initial idea into a project-specific case of intervention, through the identification, specification and comparison of different options, designed to take different approaches to the realization of the idea. Different construction techniques have been suggested, in order to minimize the cost on the new structure.

But the key factor in judging the operation more difficult to pursue is related to the massive investment to support both in terms of maintenance (the roof has currently numerous water infiltrations and spread molds) and from a facility management point of view (the costs for HVAC have significantly influenced the cost-benefit analysis). Only a multidisciplinary approach like the one proposed by BIM systems can give a general overview that allows an objective analysis of different matters.

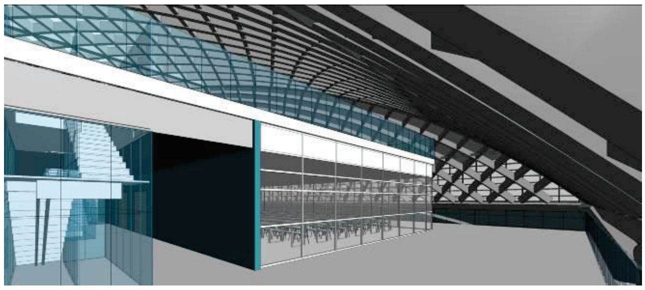


Fig. 4 Internal view

2.4 The new Energy Center

The project that best expresses the reasons that lead to the drafting of a FEA is the so called Energy Center, an intervention financed by European funds for the construction of an exemplary and innovative building in terms of energy savings. The institutions involved are the Comune di Torino, the Politecnico di Torino, FinPiemonte for work coordination, on the basis of the actors involved for the production of a shared document that carries to hypotheses and scenarios of governance and the economic and financial guidelines. At this regard, the Integrated Territorial Program (PTI) of Torino, named "Energy sustainability as a development factor: a planning for Torino" has as its overall objective to promote sustainable socio-economic development of its territory, providing for the implementation of measures which, linking together by relations of mutual interdependence, point to make the theme of sustainable energy as a strategic factor for the growth of competitiveness.

The PTI includes all the four priorities that the region has identified for its development: in detail, the program is divided into four areas:

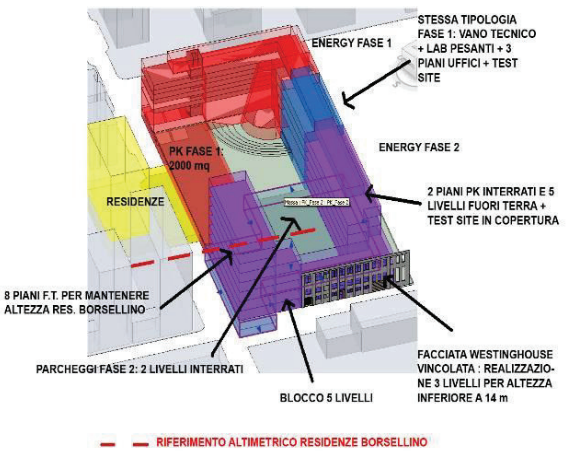
1) renovation of buildings public;
2) active policies to promote energy saving and use of renewable energy sources;
3) innovation hub dedicated to environmental issues;
4) technical training on energy issues.

The development of design concepts derives from the ongoing comparison between the professionals of local authorities and the partnership invited to participate in the working tables, in relation to the different expertise and skills. The Energy Center will aim not only to coordinate research activities and specific training taking place within the University (as also happens in other similar European universities) but also it would be a physical place of incubation of new businesses and providing services to the territory.

For this reason, continuous and manifold synergies between the various players of research and technological innovation will contribute to the development and deepening of the issues relating to energy efficiency, about the use of renewable sources to produce clean energy and reducing emissions pollutants. This would be a Center for research, but also an example and a model to disseminate sustainable energy concepts and correct behaviours. Piemonte has approved[5], the regional call for the "*financing of redevelopment of disused sites*" which are allowed to finance projects submitted by local governments for the "recovery of abandoned sites (including industrial sites) and their conversion for the attraction and establishment of economic activities and production and service" - the Energy Center meets the objectives of that announcement, in line with regional addresses of the second Strategic Plan of the City of Torino. The Politecnico di Torino considers this plan as a strategic element to strengthen its research and advisory services with a multidisciplinary approach, multi-service and customer oriented to companies;

The first step consisted in the drafting of the Plan variation, to be expected within the site of intervention. It is expected therefore a plan divided into different time phases that involves the construction of the first part, (the Energy Center) to be followed by future construction of other buildings in order to saturate the amount of free floor area achievable within it. In this regard, the BIM software lets you organize parametric interventions depending on the time variable. Doing that, it has been created an overall master plan containing the maximum heights achievable in individual buildings, with its own car parks (estimated in 40% of the GFA realized). The whole site has a building capacity of 25000 square meters, (which should equal about 10000sqm of car parks) divided into:

- Phase 1: construction of the Energy Center, about 5000sqm with underground car park of approximately 2000 square meters (highlighted with red colour in the picture below).
- Phase 1B: construction of house for students, with basement level car parks (Yellow).
- Phase 2: completion of the project with additional blocks of different types (blue and purple), depending on their use and the existing urban fabrics.



[5] *(det.n.161 of 06.07.2009 as part of the Activity III.2.1 POR FESR 2007-2013).*

Fig. 5 Internal subdivision of the area

Before reaching the final solution, in agreement with what is explicitly required by relevant regulations, there have been several proposals of distribution, as can be seen from the pictures below. In the first it was proposed the construction of a new building that resumed the former of Westinghouse headquarters, an industrial building. A part of these still remains within the site. The poor conditions of the building, (which is bound exclusively the facade) and the analysis on solar studies have focused the first building on a different location, as you can see in the picture below. (The red building is the funded one, as we discussed earlier).

Fig. 6 3D Conceptual model. First version

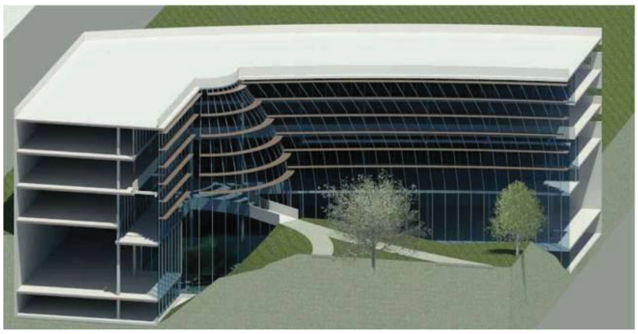


Fig. 7 Perspective section

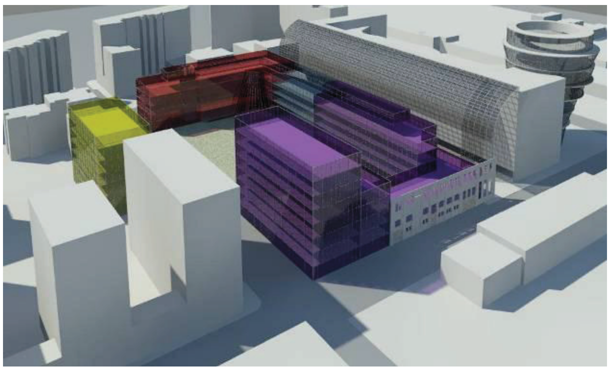


Fig. 8 General master plan. First version

After several meetings that occurred with the heads of the different technical areas (planning, technical services, construction, environment, economic development) it was decided to define a different configuration, as proposed in the image below, next to the volume of the Bellini library.

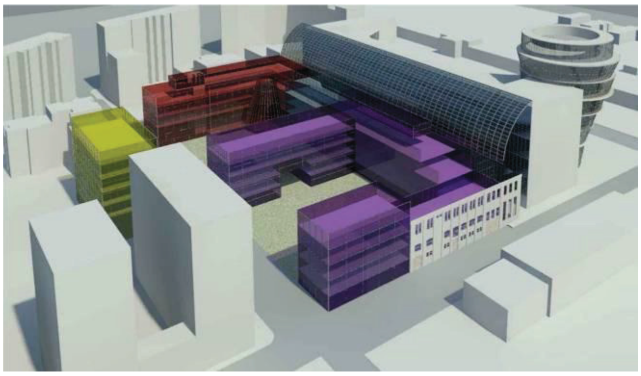


Fig. 9 General master plan. Last version

As mentioned above, despite the images presented obtained by the three-dimensional conceptual models, it should be emphasized once again the flexibility of these processes that allow correlating heterogeneous information, as a multidisciplinary feasibility study should contain.

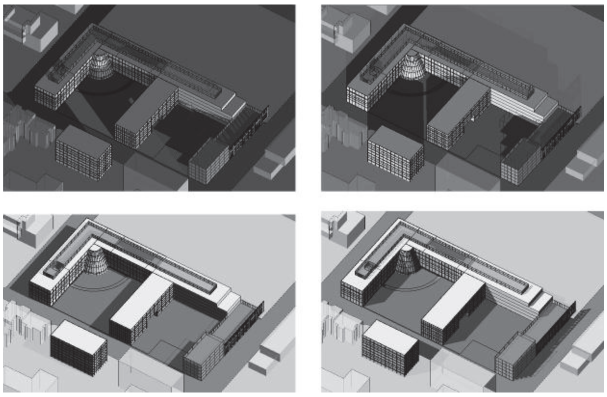


Fig. 10 Energy Center: solar studies

1_Abaco dei pavimenti edifici SP Fase 1			
Famiglia e tipo	Livello	Area	Commenti
Pavimento: REI 60_ pavimento 30 cm	A_ 0_PT_Calpestio Lab Pesanti (0,00)	849.92 m²	REI 60
Pavimento: REI 60_ pavimento 30 cm	A_ 0_PT_Calpestio Lab Pesanti (0,00)	133.00 m²	
Pavimento: REI 60_ pavimento 30 cm	A_ 0_PT_Calpestio Lab Pesanti (0,00)	222.44 m²	
Pavimento: Pavimento non compartim	A_ 0_PT_Calpestio Lab Pesanti (0,00)	72.53 m²	
		1277.89 m²	
Pavimento: Latero Cementizio - 30 cm	A_0.5_Calpestio Piano primo (4,00)	6.54 m²	
Pavimento: Latero Cementizio - 30 cm	A_0.5_Calpestio Piano primo (4,00)	6.52 m²	
Pavimento: REI 60_ pavimento 30 cm	A_0.5_Calpestio Piano primo (4,00)	143.83 m²	
Pavimento: Pavimento non compartim	A_0.5_Calpestio Piano primo (4,00)	49.58 m²	
Pavimento: REI 60_ pavimento 30 cm	A_0.5_Calpestio Piano primo (4,00)	87.39 m²	
		293.87 m²	
Pavimento: REI 60_ pavimento 30 cm	A_1_ Calpestio Lab leggeri (8,00)	296.00 m²	
Pavimento: REI 60_ pavimento 30 cm	A_1_ Calpestio Lab leggeri (8,00)	612.94 m²	
Pavimento: REI 60_ pavimento 30 cm	A_1_ Calpestio Lab leggeri (8,00)	171.06 m²	
		1080.00 m²	
Pavimento: Pavimento non compartim	A_2_Calpestio Uffici (12,00)	612.94 m²	
Pavimento: Pavimento non compartim	A_2_Calpestio Uffici (12,00)	296.00 m²	
Pavimento: Pavimento non compartim	A_2_Calpestio Uffici (12,00)	171.55 m²	
		1080.48 m²	
Pavimento: REI 60_ pavimento 30 cm	A_3_Calpestio Uffici 2 (16,00)	222.34 m²	
Pavimento: REI 60_ pavimento 30 cm	A_3_Calpestio Uffici 2 (16,00)	725.42 m²	
Pavimento: REI 60_ pavimento 30 cm	A_3_Calpestio Uffici 2 (16,00)	352.25 m²	
		1300.01 m²	
Pavimento: REI 60_ pavimento 30 cm	A_4_Calpestio Test Site (20,00)	1331.94 m²	
		1331.94 m²	
Totale generale: 19		6364.20 m²	

Fig. 11 Schedule of Ground Floor Area, phase 1

3 Sustainable Construction and BIM: design for the representation and analysis tool (M.Vozzola)

Nowadays the value of green building construction is increased: for several reasons, not the least of which is global climate change, sustainable building has become a practice of critical interest. Sustainable buildings minimize the use of resources such as energy, water, materials and land through optimal design [13]

Architects, designers and engineers are using Building Information Modelling (BIM) to help accomplish a variety of tasks more efficiently than in the past and some than might not have even been possible. The new approach to design is based on the rise of the amount of building information and the data are shared with the others team members.

The research aim is to develop and explain the two current and growing movements in the architecture, engineering, and construction industry: sustainable design and building information modelling. The goal of the BIM methodology is to allow an overall view of the building or project by including everything in a single source model.

The strategies of a BIM process is directly correlate into a sustainable design plan: for example the building model can be used during the material selection stage, the building database can be used to estimate cost and performance, and designers can put data in the BIM model that geographically locates the building.

The ability to set sustainability goals early in a project, set recycling percentages, and limit delivery ranges to decrease fuel loads all are a change in process to follow a more integrated approach to design and construction.

A Building Information Model represents the building as an integrated database of coordinated information. Beyond graphically depicting the design, much of the data needed for supporting sustainable design is captured naturally as design of the project proceeds. In addition, the integration of Building Information Model with performance analysis tools greatly simplifies the often cumbersome and difficult analysis. This approach gives architects easy access to tools that provide immediate feedback on design alternatives early on in the design process. Eddy Krygiel and Bradley Nies[6] indicated that BIM can aid in the following aspects of sustainable design:

- building orientation (to select the best building orientation that results in minimum energy costs);
- building massing (to analyze building form and optimize the building envelope);
- day lighting analysis;
- energy modeling (to reduce energy needs and analyze renewable energy options such as solar energy);
- renewable energy;
- sustainable materials (to reduce material needs and to use recycled materials) [14].

As any designer can attest, design is a cyclical process. The process of design, especially sustainable design, can involve a series of intuitive and creative movements. The Green BIM project is explained in two different case studies, Auditorium of Politecnico di Torino and Radicondoli Resort buildings in Tuscany.

The two case studies, different from each other, have some common characteristics, which allow you to compare the results obtained in the two studies and to assess the benefits of using BIM systems on historic buildings.

In particular, the buildings have the following common characteristics:

- presence of historical buildings of different types;

works on existing buildings (scope of works covered: extensions; material change of use and change of energy status; work on controlled fittings and services; renovation work);

disposal of non-residential use;

need for action on energy efficiency of the system.

3.1 BIM use for daylighting

In particular, Politecnico di Torino Campus includes different types of use and building such as:

Corso Duca degli Abruzzi site, this site was inaugurated in November 1958, since the original planning choices, it was clear that the building was meant to represent the dignity of the institution;

Cittadella Politecnica site, called “Raddoppio del Politecnico”, it is a plan for doubling the old university’s area in a former industrial area.

During the renovation work of the University headquarters, the plan had some aims, one of them was to redesign the interior courtyards.

Politecnico case study [15] addressed the issue of re-functioning of one of two inner courtyards of the University Auditorium. The objective was to create a place that can accommodate the conference attendees and participants during the different events hosted in the University Auditorium.

The project was elaborated only as BIM model, this choice has allowed us to characterize the objects in which were included many parameters of control and verification.

The potential for the development of the model in a BIM were found in the analysis of the shadows study. The analysis of the shadows study, which in this case the new functions of an external place, was to assess the correct positioning furnishings, in order to make the most of natural sunlight the courtyard. The ability to geo-reference the model by including the true North Project and to choose the date and time for the shadows simulation, has offered a range of parameters to which the project had to respond.

In particular the solar analysis model was created to understand the value of shading in the court and against the building façade. A massing model was built to understand the solar movement and various shading schemes were created to help the effects of the sun in the area.

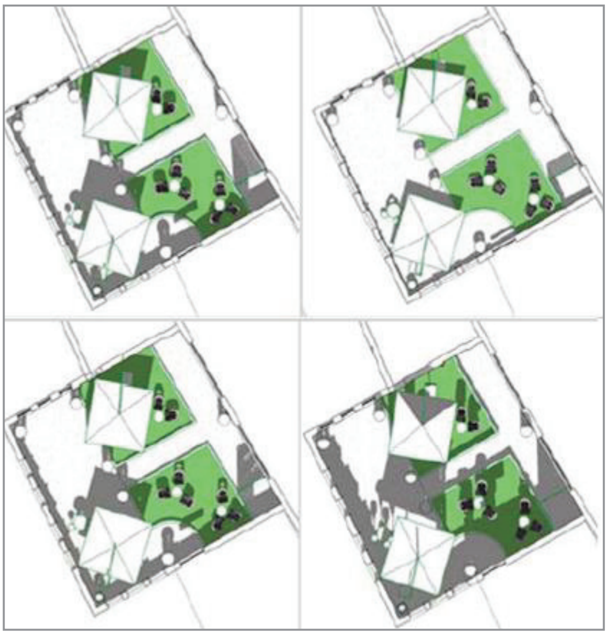


Fig. 12 Sun studies at various times of the year

The uses of BIM for green buildings have evolved in recent years, day-lighting analysis has emerged as an early benefit for many BIM adopters. Among those who use BIM for sustainable design, the vast majority conduct lighting and day-lighting analysis with BIM and related tools. For architects and engineers, this provides the opportunity for a more effective and robust iterative design process that can drive more informed choices regarding a building’s performance[7].

3.2 BIM and Sustainability

Radicondoli Resort, instead, comprised of 688 hectares of land, and includes different types of use and building such as:

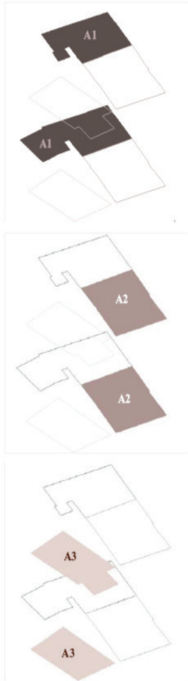
- a XII century Castle, called *Castello di Montingegnoli;*
- a mediaeval village, called *Borgo;*
- 10 rural Tuscan farmhouses, called Case Coloniche, scattered within the property.

[6] *Eddy Krygiel, AIA, LEEP AP is a pacticing architect at BNIM Architects. Bradley Nies, AIA, LEED AP, is a registered architect and Director of Elements.*

[7] *Green BIM. How Building Information Modeling is contributing to Green Design and Construction – Smart Market Peport – Mc Graw Hill Construction, 2010.*

Fig 13 Podere Tremoli (one of Case Coloniche) - Render

Our plan is based on the renovation, rehabilitation and conversion of the Castello, the Borgo and Farmhouses. A group of architects, designers and historic preservationists with strong design expertise and local experience has already been engaged to coordinate the project. Our goal is to preserve the historic and architectural integrity of each building meeting all local design and building codes, and improve the energy efficiency of historic buildings.
The image that will be offered guests an environment characterized by the charm of history: the guidelines of the project will be to maintain, restoring and enhancing all the original architectural characteristics. Stone walls or brick, wood beam ceilings, stone staircases, terracotta floors and wooden window frames will be used. The restoration of Montingegnoli Castle maintains the original distribution system. The units will be made through the union of several rooms, whiles maintaining the distribution scheme and original master plan.
For this project, we focus our attention on the Coloniche. They are the old rural farm houses where people working for the farm's owner used to live. The houses are isolated and scattered within the property. The buildings have been abandoned from many years and in some cases the deterioration through the years has reduced them into ruins. Our plan includes the restoration of a total 6488 mq converting these buildings into 39 apartments.
The BIM model was used initially in the preconstruction phase and then implemented fully when the concept design began. All documents are now being produced from BIM file and the BIM model is assisting in integrating the team and the process. The integrated design process allowed us it capitalizes on the value of sustainable opportunities at the beginning of the process.
This experience is crucial to explain one of the main benefits of BIM: the ability to use the building geometry from the model in other applications to speed some of the analysis that need to occur for sustainable design principles.



A1 - Ground Floor	
Entrance Hall Living	81 mq
Kitchen	18 mq
Dining Area	24 mq
Study	26 mq
Bathroom	14 mq

A1 - 1st Floor	
Hall	6,5 mq
Master Bedroom Suite	49 mq
Second Bedroom Suite	30 mq
Third Bedroom Suite	43 mq

A2 - Ground Floor	
Entrance Hall Living	57 mq
Kitchen	26 mq
Dining Area	26 mq
Sauna Gym	23 mq
Bathroom	10 mq

A2 - 1st Floor	
Hall	18 mq
Master Bedroom Suite	34 mq
Second Bedroom	20 mq
Third Bedroom Suite	52 mq
Bathroom	16 mq

A3 - Ground Floor	
Entrance Hall Living - Dining	74 mq
Kitchen	14 mq
Storage	4 mq
Hall	2 mq
Bathroom	8 mq

A3 - 1st Floor	
Hall	18 mq
Study	21 mq
Bedroom	16 mq
Second Bedroom Suite	24 mq
Master Bedroom Suite	43 mq

Fig 14 Podere Tremoli –Table of rooms and squares

It is important to recognize that many strategies are both cumulative and interdependent. Addicting some strategies on top of others can have a compounding benefit: building orientation, glazing and daylighting are some of the most important one. Capitalizing the building direction, using the right glass in the correct amount and location and integrating sun shading into the project to optimize the use of natural light all build on each other.
Understanding and capitalizing on the model components parametric relationship, we could optimize the integrated strategies and technologies for a sustainable design requires.
In this context and with these objectives has been set BIM work: from the early stages of survey and design were controlled quantities and types of materials used. In the project, we have established a goal to use predominately three different kinds of material:
- reclaimed materials – not only from historical buildings;
- recycled materials;
- locally produced materials [16].

To analyze the cost-effectiveness of various sustainable strategies, we developed a model building in BIM to run our energy modeling software. For energy analysis you can import the model into energy programs to determine the efficiency of the building. The choice of software depends on the type of analysis desired[8].
The combined future of sustainability and BIM can help us move to a restored world and a healthy planet; we could move faster and more elegantly using BIM for Sustainability, this union could be of great benefit. It is possible achieve feedback from material changes, design changes and orientation changes fairly quickly. The Integration of BIM and sustainability is very important for

[8] Ben Ridderbos, LEED AP, Vikram Sami, LEED AP,SOLAR 2010: Building Information Modeling (BIM) & Sustainability – Using design technology for daylight modelling, http://www.ases.org/papers/160.pdf

the future of the design industry since the ultimate goal of both targets efficiency.

4 Conclusion

The paper aims to show, through the description of different case studies, the new design drawing which characterises the BIM approach: the added value is clearly seen in the ability to organise and share a series of different types of data usually processed by different software applications which are often not connected. Users are in fact obliged to make decisions which either because of a lack of time or dialogue between designers, are postponed until the implementation stage of the design, when major changes are either very difficult or too costly.

Acknowledgement

Thanks to the Building Service structure of the Politecnico di Torino for having allowed the publication of the scientific results of the latest design operations that involve the same University.

References

E. Persico, Profezia dell'architettura, 1935 cited by Saggio Antonino, "Nuove sostanze. L'informatica ed il rinnovamento dell'architettura. Un manifesto per l'architettura dell'informazione" in "Il Progetto", n. 6, January 2000.
M. Galli, C. Muhlhöff, Terragni virtuale. Il CAD nella ricerca storico critica, Testo & Immagine, Turin, 1999, published in English "Virtual Terragni. CAAD in Historical and Critical Research", Birkhäuser, Basel, 2000.
M. Meossi, Info-Architetture. L'architettura performativa dell'età dell'informazione, in Esempi di Architettura, year I, n. 3/2007, pp. 13.
G. Corbellino *Parole chiave – Diagramma*, in *Arch'it (*www.architettura.it), 2004.
B. Van Berkel, C. Bos., *Move I Tecniques*, UN Studio & Goose Press, Amsterdam, 1999, p.21.
B. Hamburger, Exact and approximate dimensions. Towards an heuristic of design, in Lotus International, n. 37, 1983.
A. Saggio, Introduzione alla rivoluzione informatica in architettura, Carocci, Rome, 2007.
A. Saggio, Introduzione alla rivoluzione informatica in architettura, Carocci, Rome, 2007, pp. 101-105.
G. Devoto, G.C. Oli, *Dizionario della lingua italiana*, Le Monnier, Firenze 1971.
C. Eastman, K. Liston, R. Sacks, P. Techolz, BIM Handbook: A guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractor, Hardcover, Marzo 2008.
B. Hardin, *BIM and Construction Management, proven tools, methods and workflows*, SYBEX and Wiley Publishing Inc. , Indianapolis, Indiana 2009.
G. Cangialosi, M. Lo Turco, M. Rebaudengo, *Project and Quality Management at Politecnico di Torino*. In The 1st International Conference on Information Science and Engineering (ICISE 2009). Nanjing, China, 26-28th December 2009.
B. Turner, Getting to Green: Sustainable Building Design and BIM, Acronym Magazine, Issue 7, 2010.
S. Azhar, J. Brown, R. Farooqu, BIM-based Sustainability Analysis: An Evaluation of Building Performance Analysis Software, in Green BIM, Successful Sustainable design Building Information Mode, Wiley Publishing Inc, Indianapolis, 2008.
M. Vozzola, L'utilizzo del Building Information Modeling per il disegno di progetto, la rappresentazione e la comunicazione dei dati del processo edilizio, Doctoral tesi in "Rilievo e Rappresentazione, Conservazione e Restauro", Torino, 2009.
AAVV, Green BIM, Successful Sustainable design Building Information Mode, Wiley Publishing Inc, Indianapolis, 2008.