Ambienti collaborativi per la condivisione della conoscenza: prime applicazioni di Building Information Modeling in ambito pubblico - Collaborative environments for knowledge

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Collaborative environments for knowledge sharing: first Building Information Modeling applications for Public Works

Ambienti collaborativi per la condivisione della conoscenza: prime applicazioni di Building Information Modeling in ambito pubblico

Nowadays the role of new digital technologies is in constant evolution if compared with the more established practices. They are based on a systemic and relational approach that suggests (or better imposes!) to evaluate the limits and virtues, exploring new collaborative and communicative languages; at the same time, the dissemination of new tool need to be investigated in detail. Moreover, the tendering reform approved by the European Parliament extends the operational horizons of BIM methodologies.
It is intended to give substance to these topics: we will validate the proposed taxonomies through the illustration of some case studies developed through the collaboration with the Building Service of the Politecnico di Torino, which during the last years years invites professionals to attend BIM oriented procurement, according to requirements and best practices adopted in the UK, Europe and North America.

Le nuove tecnologie digitali, in continua evoluzione e perfezionamento rispetto alle pratiche consolidate, sono basate su un approccio di natura sistemica e relazionale che propone (o forse impone!) di esaminarne i linguaggi collaborativi e comunicativi, indagandone insieme gli attuali livelli di diffusione. L'azione normativa stessa, posta in essere negli ultimi anni in Europa, estende di queste tecnologie gli orizzonti operativi.
Alcune tassonomie saranno proposte attraverso l'illustrazione di casi studio elaborati nel corso della collaborazione con gli uffici dell'Area Edilizia e Logistica del Politecnico di Torino, ateneo che da qualche anno, per le attività di manutenzione straordinaria e per gli importanti lavori che ne stanno ampliando spazi e funzioni, invita i professionisti a partecipare ad appalti BIM oriented, in linea con le principali best practice adottate nel Regno Unito, Europa e Stati Uniti.

keywords: Minimum Modeling Requirement, BIM, Public Law, building site
parole chiave: *Minimum Modeling Requirement, BIM, Normativa, Lavori Pubblici, cantiere*

INTRODUCTION MLT MMB

In recent years, the construction industry is experiencing a period of great changes in a fervent renewal of its knowledge, praxes and technologies. Taking a cue from some philosophical influences that have been dealing with the subject of social ontology, with a focus on documentality [1] that revolves around the building issues, we introduce some thoughts through the analysis of claims that relate subjects, objects and institutions [Ferraris, 2009].
The first among them can be ascribed in the legal-institutional disputes, in relation to recent legislative dictates, measurable at national and international scale, of which we will analyze the main steps, with particular reference to the impact in the field of Public Works.
The second controversy regards methodological-instrumental aspects, referring to the recent development of BIM (Building Information Modeling) procedures that actually trigger comparisons, discussions and differences of opinion every day replicated in different contexts which refer to research, education and profession.
It's useful to think about the possibility of proposing knowledge and training in academic experiences aimed to future professionals that reveal themselves as an improvement of skills and abilities appropriate for the required commitments of the construction sector.
The analysis developed in the following paragraphs, which caters mainly to illustrate some of results conducted between profession and research, puts the spotlight on a strain that appears binding and that concerns the relations between system of relationship required inside design and manufacturing process: they will be asked to measure the opportunities offered by research of the drawing discipline, while continuing to operate in the specificities of the different technical fields.
Focusing the scope, this contribution is intended to give substance to the previous assertions, validating the proposed taxonomies through the illustration of some case studies developed through collaboration with the offices of the Building Service of the Politecnico di Torino. This department is one of the few public General Contractor (where strong it was the mixture between research, education and profession) which for some years invites professionals to attend BIM oriented contracts involving third parties external to the University structures, presenting itself as in line with regulatory requirements and with the main best practices adopted in the UK, Europe and the United States.
The representation, by defining the scientific bases of the drawing discipline, is a knowledge tool that reveal the laws that rule the formal structure of the contents; to be an interpreter of building transformation processes, it must necessarily investigate methods, techniques and procedures that govern the data containers and the information flows that depart from these. From the side of the Drawing, and beyond the usual representations, whether we intend to explore the significant reasons of survey theories or those related to the design, we are certainly working a renewal of processing, useful to produce different levels of knowledge and new shared place dedicated to exchange and discussion of the assumptions, but with such possible applications?

SOME ISSUES ON THE MAIN NATIONAL AND INTERNATIONAL NORMATIVE REQUIREMENTS MLT

The adoption of BIM methodologies in many foreign countries, together with the reform of contracts voted in the European Parliament (European Union Public Procurement Directive, EUPPD), reveals an increasing demand of using BIM methodologies in the activities leaded by construction industry for public works.
The adoption of the directive means that the twenty-seven EU Member States may encourage, require or compel the use of BIM from 2016, as will happen in the short to England, the Netherlands, Denmark, Finland and Norway where it is strongly required for construction projects financed by public funds: this means that in a not too distant future will be binding deliver not only the elaborations on paper, but also georeferenced three-dimensional digital models, drawn up while respecting the norms and conventions derived from professional practice, from which multiple information may be obtained and which will be implemented the project validation procedures, with obvious legal implications related to the degree of reliability of the model [Lo Turco, 2015].
As far as the Italian legislation on Public Works, the Reformation of the contracts will start in stages: recently the Environmental Commission of the Camera dei Deputati gave the green light to the draft law, paving the way to rewrite the rules governing public contracts.
Recent developments foreseen by the Legislative Decree n. 50 of 2016 aimed at streamlining the project activities of the works of a public nature and their checks, including through the progressive use of specific electronic methods and tools. A new role is given in particular to the feasibility studies (which in fact should be replace, with a new formalization, preliminary design) and the development of interoperable data formats on open platforms of cooperation.
As well as the international and professional practices have impacted on recent legislation - which comes to include procedures for management of the construction process in the direction of greater transparency and sharing - so the effects of this new vision of the legislature surely will prove as regulator to rapid changes already underway in the professional, thus establishing a virtuous circle that should promote and support a strong advancement and progress of the methods and techniques of production.
The representation for the building process, even of graphical type, not only is not indifferent to these more structuring and formalized paradigms (much more significant than those pervasively incorporated in the Eighties transition from traditional design methods to computer aided design), but it continues to be proactive and central actor of information flow. This effect could be increased when Drawing include automatic data management foundations, or rather, get in cooperation with, assuming they as additional cultural foundation, not seeing them as outsiders, even their theoretical and practical elements that assume data as resultant of components of different format and origin.
With different implications, regulatory updates, even without naming them explicitly, identifies both building information modeling methods and data management as the basis of the design process and construction. From the feasibility study of the artifacts until their realization and implementation, they in fact facilitate continuous interaction between the different professionals and various bodies responsible for monitoring throughout the construction process.
A common feature of different elaborations is a relational database, as it contains all the qualitative and quantitative specifications with regard to the elements involved by the different project ideas till to the realization of the performance aspects in relation to the requirements and the needs set by the customers and

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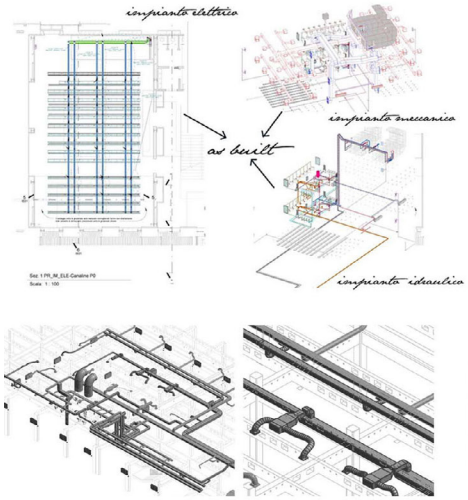
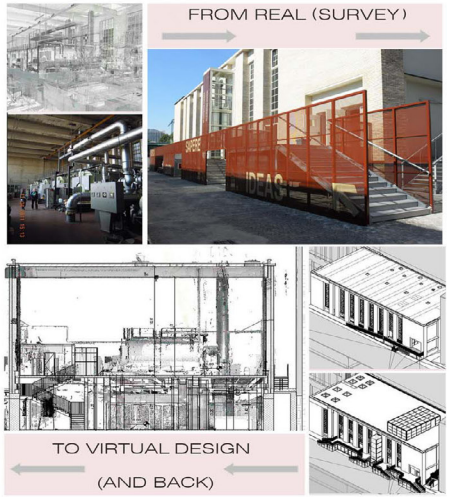
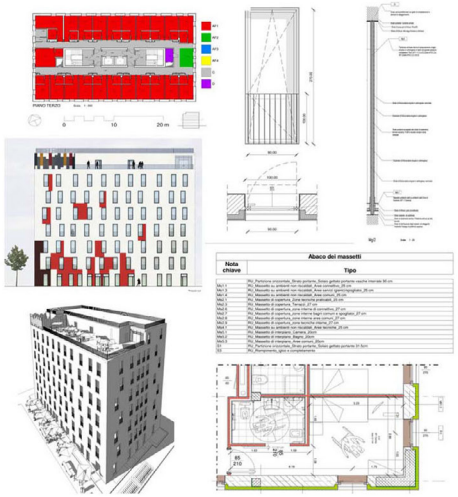


Integrated BIM design and clash detection between several disciplines. Restoration of the 5th floor of Lingotto and design of new classrooms. Amount of works: 2 mln €. Client: Politecnico di Torino (2015)

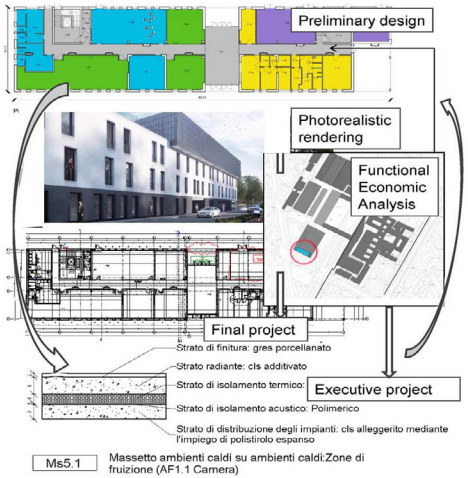


Restoration of the old heating stuff e new classrooms. Metric survey through Terrestrian Laser Scanner. Amount of works: 2 mln €. Client: Politecnico di Torino (2012)



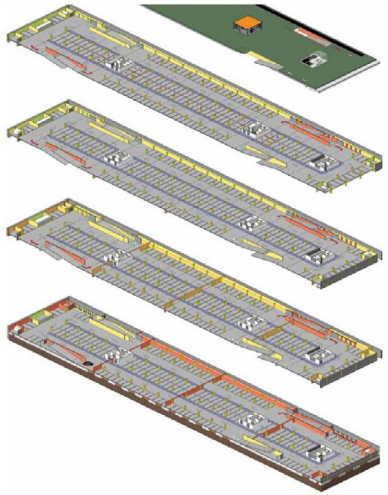
Final architectural design of Codegone's residence. participation in the ministerial ban. Amount of works: 11 mln €. Client: Politecnico di Torino (2011)

DEVELOPED DESIGNS AND EXPERIENCES



Final architectural design of Mollino's residence. participation in the ministerial ban. Amount of works: 11 mln €. Client: Politecnico di Torino (2011)

Preliminary design of new Energy Center. Amount of works: 14 mln €. Client: Politecnico di Torino (2015)



Preliminary design of the undeground parking of the Cittadella Politecnica. Amount of works: 20 mln €. Client: Politecnico di Torino (2011)

Figure 1 Summary of the most interesting interventions developed in BIM environment over the past five years through collaboration with the Servizio Edilizia e Logistica of the Politecnico di Torino. (Authors: M. Lo Turco, G. Cangialosi)

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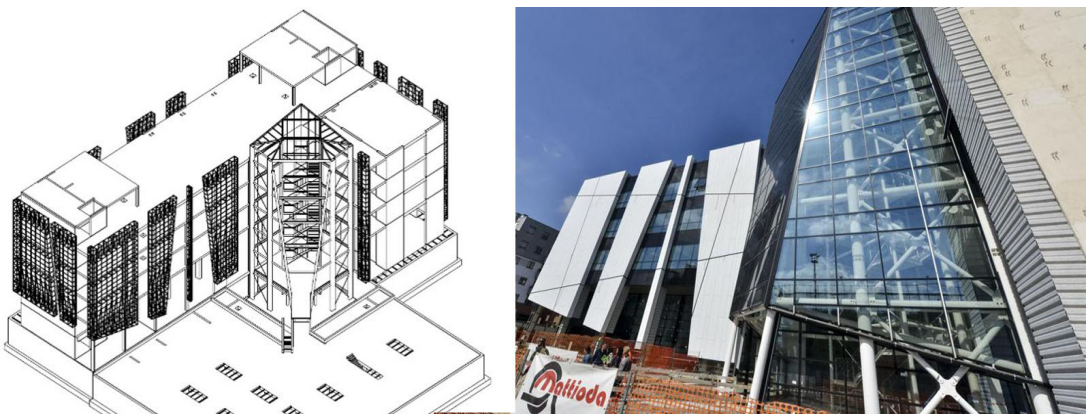
designers.
With this vision, the drawing tools are upgraded to support a cognitive process that is no longer a collection of static snapshots of the container of information, but rather arises as a fluid sequence of exchanges of data that can be captured through continuous and progressive still images.

FROM THE METHODOLOGICAL / INSTRUMENTAL DEVIATIONS TO MEASURES OF RELIABILITY OF INFOGRAPHIC ASSETS MLT

Frequently we hear about BIM methodologies or BIM tools. It is useful to operate a distinction: historically the term tool means not only the physicality of the medium through which we can operate, but also the scientific and intellectual condition which is determined by the progress of a procedure.
An utensil is indeed "something ... prolonging and reinforcing the action of our limbs, our sensitive organs, something that belongs to the world of common sense. And that can never let us overcome it. [...] The tool instead - ... is not an extension of the senses, but in its most strong and most literal meaning, the embodiment of the spirit, the materialization of thought" [Garzino, 2011].
Over the centuries the system of knowledge is often related with systems that would allow the innovative formalization: it's been that way in Brunelleschi and perspective frame, in Caravaggio and the darkroom, in Galileo and his telescope, etc. So, there is a close link that bind drawing of BIM on the one hand with the culture and history of the design and on the other with the path of knowledge in Western philosophy, fact that constitutes a founding legitimacy and gives to the chosen procedure the dignity of tool and not only the role of utensil.
This radical change brings with it countless theoretical and epistemological implications, with obvious and immediate impact on the mode of representation where the virtual model (or virtually modeled building) becomes itself a reference from the contractual point of view for the whole building process.
Then the accuracy of the representation and the completeness of information that it produces are not only related to the metric scale of the drawing, but rather to the way in which the same element is described, not only in its graphical way, through progressive steps that leads to the definition of the whole realization.
A BIM model could therefore provide information regarding shape, size, technical and material characteristics, costs, etc. that the author did not intend to give in that particular design phase, or even that he did not believe they could be found for a particular use.
Precisely for this reason in every design step is essential to communicate the information basis of each design element to involved professionals, from the early stages until the executive definition of the designing idea, explaining at any time what information is actually reliable and which are not; this is a concept that not always interacts with the graphical representation of the model.
Referring to usual normative issues of Countries where it is most in use, the level of confidence and the aims must be uniquely defined. To match this requirement the concept of Minimum Modeling Requirement was developed; it can define the level of detail that the model and its various parts should have at different stages of the design process, BIM Information Exchanges protocols have been developed and the idea of LoD [2] has been incorporated binded with the information package that belongs to a BIM model: LoD defines what and how much part of complete information is actually usable.
In the Protocol of 2008, the American Institute of Architects decided to own the concept of LoD, but also extending it to other uses, such as energy analysis and chronoprogramming. With this purpose, he renamed the term with Level of Development. The LoD acronym leaves it open to multiple interpretation: it is appropriate to distinguish between Level of Detail [3], generally used to define the level of detail of any component, and Level of Development which indicates more precisely the degree of reliability of the information associated with building components and their graphical representation.
The BIM Information Exchanges protocols usually consist of tabular documents that define the level of completeness that has to be achieved at each stage of the design process. This protocol is an integral part of the BIM Execution Plan, a contract signed at the beginning of the process and responsible to provide an overview through the explanation of roles and responsibilities of the members of the design: it becomes binding between the various actors of the design process, relative to one another and with respect to the principal customer, in reference to the figures responsible to verify its accuracy.
Compared to the level of graphic definition (usually referred as Level of Detail) an important reference is undoubtedly the AEC (UK) BIM Protocol [4] which defines various degrees of model definition and

Figure 2 Energy Center: Structural executive design carried out in BIM environment (Cangialosi, 2013) and construction site image (2015)



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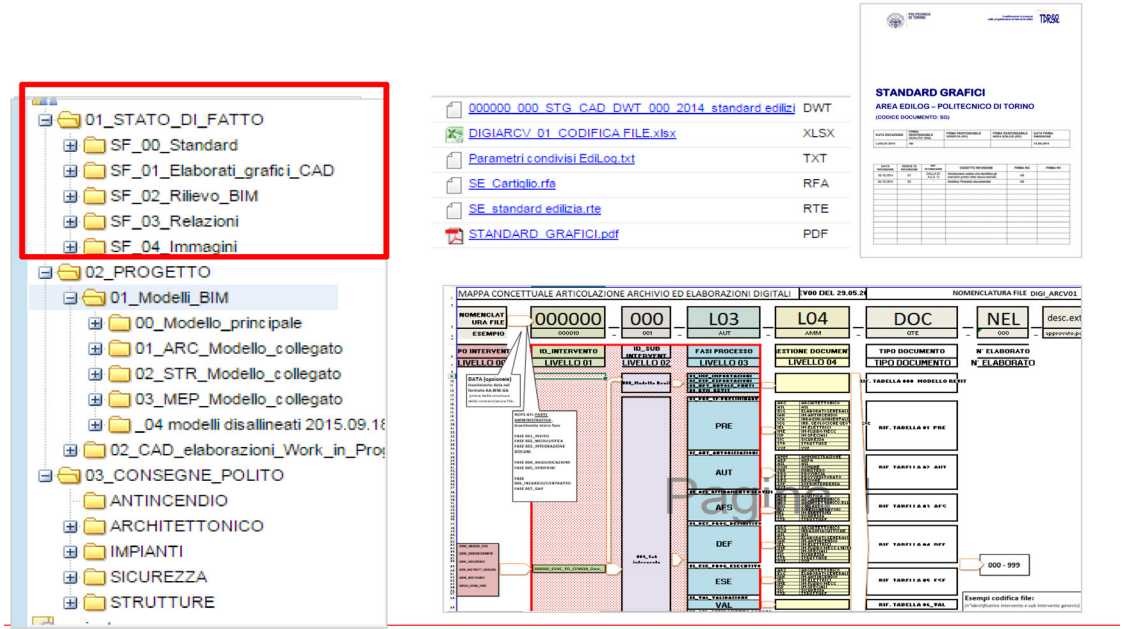
specifies that they are completely independent from its attached information and metadata, hybridization between elements with a very low degree of graphic definition but accompanied by all the product data and installation can be present.
The framework results complex and articulated, characterized by multiple interpretations that the various subjects propose (or impose!), standing the momentary institutional gap (legislation), which is still in its infancy. What should we do in front of this Copernican revolution? What are the essential steps and operational strategies that allow Public General Contractor to manage these changes in a coscentious and diriment manner? The experience conducted within the Area Edilizia e Logistica can be a useful reference to outline the essential steps to respond proactively to the issues raised above.

THE REPRESENTATION OF THE PROCESS. THE EXPERIENCE CARRIED OUT BY THE BUILDING SERVICE OF THE POLITECNICO DI TORINO MLT

The collaboration between the DISEG (Department of Structural, Geotechnical and Building Engineering) and the Building Service (EdiLog) of the Politecnico di Torino began almost ten years ago, in a time in history when the offices entrusted to the management and planning of Ateneo structures didn't own the necessary skills to implement procedures comply with the latest BIM methodologies recently tested in the most advanced fields of research. Thanks to the coordination carried out among the teachers of Drawing and the Head of the Area, arch. G. Biscant, it was possible to proceed to a collaboration which provided on one side of theoretical insights and research, on the other a parallel of professional type experimentation to evaluate strengths, weaknesses and potential of BIM methodologies.
As an example, we didactically cite the first and outdated experiences of BIM design leaded under a mandate of the Politecnico, but later focusing on the most recent applications that illustrate the use of data bases in the BIM models in a information reuse perspective.
The first particularly complex project (2010), due to proposal extensions and construction technologies, refers to the creation of a multi-storey car park within the so called Cittadella Politecnica. Despite the design level was preliminary, the various building components were molded by means of the explanation of the different stratigraphy that constitute the different packages, so as to develop cost items through an analytic approach. The same procedure was adopted also for the design of the new Energy Center (2011), the first great realized work and recently opened.
In the same year the Politecnico participated in the ministerial ban calling for the co-financing of university residences, presenting two executive designs. The ban expressed targeted requests to operate dimensional-type controls on the relationship between the various functional areas oriented to residential, leisure and study: this was an opportunity to create a system of internal standardization procedures, which year after year were updated and integrated for the drafting of a BEP (BIM Execution Plan) and manuals for internal porpose, essential for the correct definition of flows, conventions and procedures controlled by one or more BIM Manager. The following year (2012), with the refunzionalization in classrooms for teaching of the former Centrale Termica we experienced the use ofpoint clouds for modeling a BIM environment. It was simultaneously carried out the first collaborative work procedures through the decomposition of the digital model in Worksets (object classes). Since last year (2015) the BIM design also includes the plant discipline (or MEP, Mechanical, Electrical and Plumbing), favoring procedures of clash detection (interference control) between the different involved disciplines.
This growth culminates with the publication of some ban oriented to the most economically advantageous offer for

Figure 3 Unification of procedures: from naming to organization of files, to sharing the graphics standards associated with different levels of design



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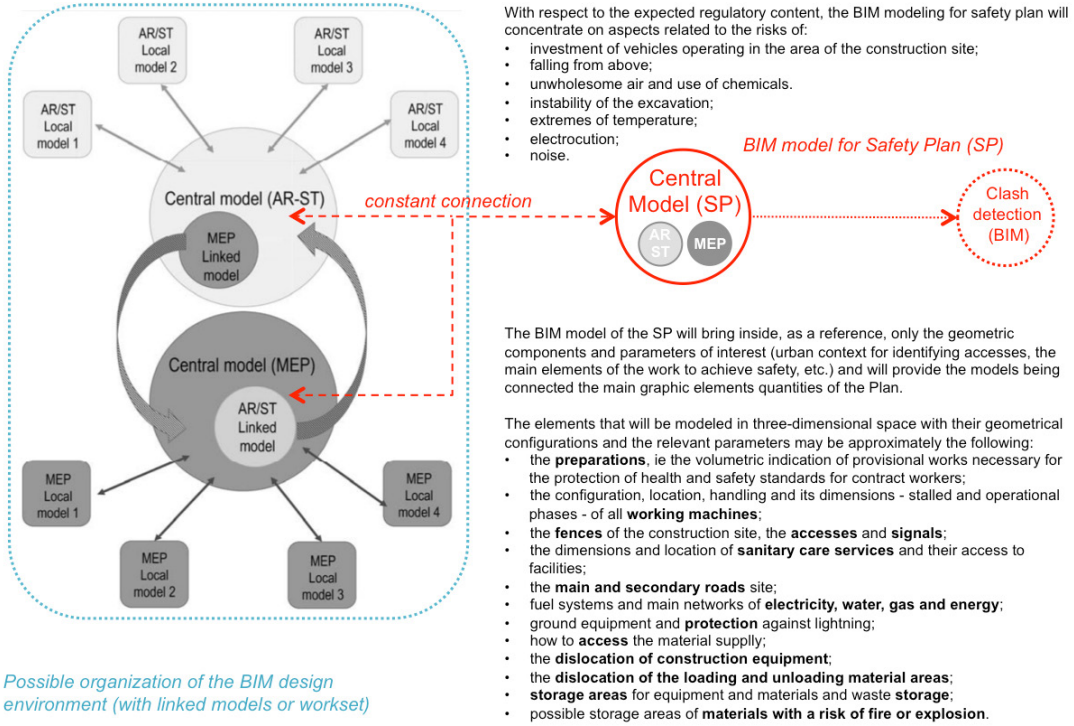
outside professionals, where he was encouraged the use of BIM applications through strong rewarding when comparative assessments were set up, denoting some experience and ability to assume directional roles, effectively combining document management procedures with the latest parametric methods.
The new challenge is to understand what are the ways to reuse the information system with an equal advantage also during construction and maintenance phases.

DRAWING FOR SAFETY ISSUES IN BIM MMB

New ways of conceiving the project within an organized flow of information spread their effects to all elaboration environments and to managers, designers, coordinators, field workers, all the professional figures involved. The issue of safety on construction sites and the protection of workers, regulated by Italian national law no. 81 of 2008, is therefore taking on an increasingly integrated view more properly connected with the designing stages.
In the interest of enhanced protection and safety of all those people involved by the execution of engineering works, in parallel to the assumption of specific and updated technological solutions for construction phases (in order to mitigate the effects of the work and the active and passive protection of people), then take a lot of importance the tools of knowledge and preventing employees from the relevant figures for the safety coordination in the design phase and during the execution of the work, in close collaboration with the design team of architectural and building works, structural and plant.
As mentioned, the Politecnico di Torino has recently boosted even the professionals working in the field of security, through rewarding in their bans issued, to adopt uniform processing tools with information and IT equipment used by design teams and operational teams on site.
These tools, including graphical ones and supported by diversified IT approaches, have much significance in the process of elaboration of the security plans, as in the coordination and control during the operational phases.
In addition to having to relate instantly with the design aspects, the BIM model proposed for the safety plans must provide a close correlation with the schedule of works to integrate the programming operational tool



Possible organization of the BIM design environment (with linked models or workset)

Figura 4 Integration of cognitive tools related to construction site safety and protection inside the traditional BIM "process"

with BIM model for safety in order to generate the representation of the plan through "updated and dynamic" views of the site in several significant moments of its life: the presence of critical processes, proper flow distribution, analysis of spatial dimensions, identification of sectors and homogeneous areas, the presence of several processes at the same time.
For specific steps identified as particularly critical for site works, it is possible to proceed to an analysis of spatial / temporal interference even with supplementary BIM tools, specifically designed to control every aspect of possible geometrical conflict (collision, footprint, reduced handling, reduction of spaces and safe routes) in relation to the time schedule of activities [Bocconcino, 2016].
The effects of a BIM management applied to all the aspects related with safety and protection, in addition to reflect on greater consistency of project works issues

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with those dedicated to safety, in close continuity with the schedule of works, it determines an exact match even with the estimative metric computation of safety items; the costs will in fact closely related with the elements of the BIM model of the Safety Plan and the building process will find full correspondence between the elaborate graphic nature and the metric calculations that arise from it.
The plan and design of the project descends from a well ordered set of elements, relationships and punctual representation rules; this order is divided into a series of predefined automations that must have explicit and shared conditions to improve and check them.

Figure 5 Work on the V floor of Lingotto building: images regarding existing situation and future realization. In the section below the MEP model to verify the passage of the plants inside the beams that characterize the structural system of the designer of the building Mattè Trucco

Figure 6 Photo diary of construction site and BIM field exemplification (University Residence C. Mollino, Politecnico di Torino, 2016, photo archive of the coordinator for site safety Eng. Dario Pezzuto, document management and BIM model by Studio Torino CABE)

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THE REPRESENTATION AND DOCUMENT MANAGEMENT FOR CONTROL OF CONSTRUCTION ACTIVITIES MMB

Construction site involves skills, produces data flows, requires sharing of documentation, information and data of technical and promotional type (verbal orders, validations, timelines, quantity surveys, textual and graphic-numeric reports on the work in progress), at specific times and with the correct level of detail.
The development of a project template through information technologies related to Building Information Modeling and Database Management System (DBMS) requires the involvement of expertise and resources specifically trained and investments in hardware and software equipment.
Not being able to "bring physically" in the construction site the BIM design model - for reasons of convenience, but also because the project template actually contains more data than actually are needed for the control of its realization - there should be a generalization of the model itself (selecting only useful aspects to monitoring and addressing the progress of realization) and computer tools for writing and updating data that are considered efficient [Bocconcino et al, 2015].
Rules of generalization and representation of the construction site model must then be prepared as the model that responds to the constructive design has to perform various purposes, each of which involves different skills and requires distinct commitment and concentration over time.
Critical point in the transition from project definition to the control and leading of the construction is the level of reliability and accuracy of the detailed design model BIM and technical documentation that defines the requirements and standards of the modeling of the construction (the execution plan of the BIM process, commonly known as Building Execution Plan), of the as built and of the operational phase.
The integrative aspects of "data management and flow of information" (for the construction and for maintenance) are strictly functional, on the one hand to the integrated work carried out by construction figures with BIM Manager, on the other to a mode of storage and management of data concerning the behavior of the artifact [Ciribini, 2013].
The correct setting of the information flow must match an orderly organization of the data produced by the work teams. The support to the BIM methodology and technology with those relating to the management systems for the basics of alphanumeric data and relational and internet services (web application supported by a database) is a field that different work teams have been experimenting for some time and operating actively in various construction sites.
Today's web applications (prepared ad hoc and dedicated solely to construction figures) in fact allow you to keep a photographic and textual diary of all construction activities recorded by responsible professionals, properly metadocumented and interrogated through multiple search filters (chronological, thematic, etc).
A section of the same system can be specialized for connection of alphanumeric parameters of the BIM model: the different construction figures have the need to record, directly associated with a work / model component, their notes, graphic sketches, photographs, digital recordings (eg related to a state of a given building element or plant), from the site and just with your smartphone or tablet, without having to "intervene" in the parametric model BIM. Or they need to retrieve information of the construction project, incorporated and resident in the model. This flow of information can be managed through shared exchange platforms.
The graphical devices that control the representation of the processing processes are configured as the back office of Drawing, allow you to check for accuracy and extend the effects and, above all, to produce the more specifically graph, measurable and recognizable.
The drawing binds itself even more closely to the data that support it (and their constant evolution) and of these highlights relationships and the quality to produce knowledge.

CONCLUSIONS MLT MMB

The proposed examples trace the essential steps that have enabled the Building Service of the Politecnico di Torino to organize and manage the first BIM oriented contracts, proving to be in line with regulatory requirements and with the guidelines / best practices adopted in the UK, Europe and America.
In particular, the construction site can therefore be considered one virtual space containing the entire digital technical support documentation to the activities of the yard professional figures. This virtual space accommodates any digital technical documentation supporting the activity of the RUP (in the local regulation the unique responsible of the procedure), of the DL (manager of construction), of the enterprise and of all stakeholders.
The realization of a unified IT platform should increase the productivity of all involved subjects - in terms of "less time" to record, share and represent the measured and calculated data graphically. At the same time, it should involve the players on a single virtual marketplace: the centrality of data and information, as well as the effectiveness and the efficiency of the building process, has also assumed the role of transparency and participation indicator.
The three-dimensional parametric model must be interoperable with the relational database and the dedicated web applications. The geometric and alphanumeric design of this model must be "simplified", i.e. strictly functional to control activities, without redundancy of geometric or parametric information.
The geometric and alphanumeric model produces construction views (drawings and text) integrated and consistent with each other and thus ensures the correct transmission of the activities in progress.
Some on site application examples have highlighted, a consistent flow of site data and an efficient data processing in the back office. The ability to export, including to field activities, the wealth of knowledge developed by the project is definitely a supporting element to the building process, that needs to be mediated by representation of protocols. The possibility to foster the database with operational data is another element to consider in the development of the executive project.
The integration of different interoperable technologies is a strength of the information system, able to connect multiple stakeholders in the construction sector. Also with respect to the building management, the system of relations will allow useful applications, even in real time, if properly implemented (dynamic maintenance book), related to living, energy consumption, flows to housing work.
The meeting place of designers and construction and management figures is not only made up of individuals and isolated computing environment processing (CAD, BIM, GIS, database management, computer software, etc.). It is an integrated and distributed container, fueled by those environments, aimed at structuring and

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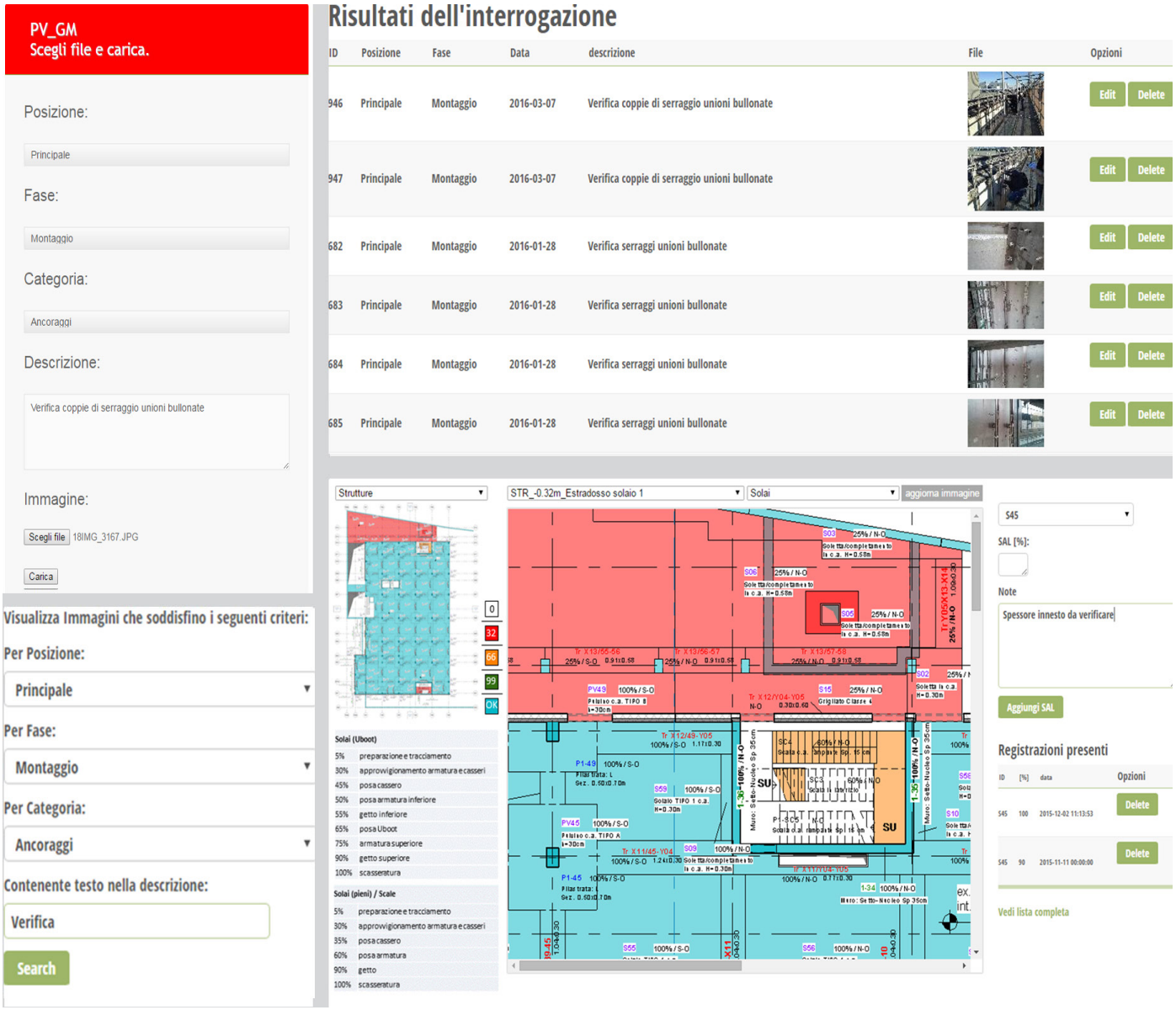

Figure 7 Document of site management system, connected to the BIM model. From top: uploading interface photographic collection via smartphone, tool for querying the repertoire and exemplification of the research outcomes, interface for the association of the states of the work to the building elements (so called SAL brought into the BIM model to organize the tables issues related to work in progress)

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making transparent the building process, a sort of common area of skills and knowledge to acquire, update and distribute the information. This is perhaps the next frontier that, after forming the boundary between geometry, measurement, and parametric models, will lead to amplify the effects of the same informational model for broader correlated fields and propagation because they don't specialize their use, opening the building flow to all professionals involved in the creation, to people living in a urban environment.
The measure of the level of reliability of prefigurations expressed through drawing is just one of the tasks expected from the actors of the building process, but for us scholars in the discipline perhaps the most complex, the most important.

NOTEs

[1] In recent months I have participated with pleasure and interest in a series of conferences and seminars with the aim of measuring the "effettualità" (a sort of efficacy, effectiveness and capacity) of the design, in their different and innumerable facets. Thank to philosophers Leonardo Caffo and Edoardo Fregonese from the Università di Torino for their contributions, as well as to the professors Giovanni Durbiano and Alessandro Armando from the Department of Architecture and Design of the Politecnico di Torino for having me involved in this working progress. Part of the considerations in the introduction are derived by Maurizio Ferraris studies, referenced in bibliography at the end.

[2] The concept of LoD was originally derived from that one of Level of Detail, developed about a decade ago by VICO Software, with the aim to specify how accurate were the information about a specific design element, with particular reference to its costs.

[3] In some international guidelines graphic content is defined by levels of GraDe (Graphic Detail).

[4] AEC (UK) BIM Protocol. Implementing BIM UK Standards for the Architectural, Engineering and Construction industry. Version 2.0 September 2012 Updated to unify protocols outlined in the AEC (UK) Standard for BIM Revit and Bentley Building. AEC 2012..

[5] With this respect, Eng. M. Lo Turco played dual activities from 2008 to 2015; Eng. G. Cangialosi is still a consultant of the offices, Eng. M. Bocconcino has carried out cooperation activities in the preparation of projects (and processes) of greater complexity.

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