The Role of Digital Technologies for Project Representation

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Abstract

In recent years construction industry is crossing an innovation process based on the digitization of information to reliably describe the existing architectural heritage. Therefore, the need to adopt a new graphic language based on information modelling that summarises graphic and alphanumeric characteristics of a certain building has emerged. This contribution focuses on the analysis of aspects that have characterized the idea of representation in the past, proposing information modeling as a natural renewal of design representation through digital technologies.

Keywords: Drawing, 3D parametric modelling, BIM, Existing building.

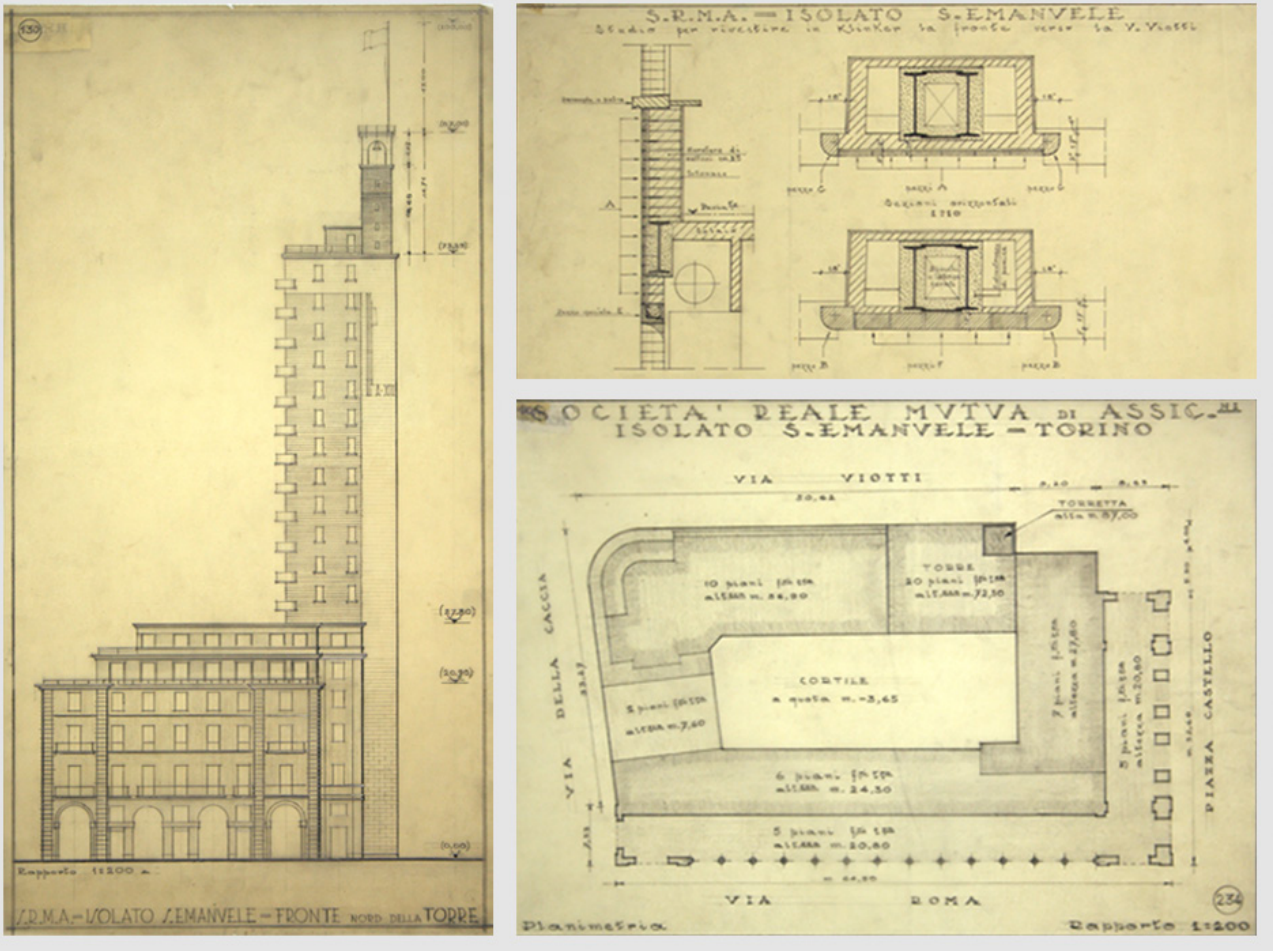
Introduction

The ability to communicate an idea or information about the project is fundamental for the human being who studied in history different ways and tools to describe reality, using various methods of representation, through drawing as a fundamental device to transmit a certain design idea.
Moving from idea to physical shape using drawing, has posed over time a series of questions about the meaning of representation to which many scientists have tried to respond with their researches. This contribution aims to explore the science of drawing, taking into account various definitions that have been given over time by scholars, clarifying the current role of digital technologies for existing heritage representation.

In XVIII century, the need of a drawing's theory was studied by Gaspard Monge who, thanks to descriptive geometry, encoded the method of orthogonal projections by defining exactly rules for representing space on the flat surface. Also in this case the drawing is declined as a necessary language both for the man who conceives a project and for those who have to realize it [Bennicelli 2006, pp. 261, 262]. One of the main challenges faced by Monge was explicit the need to describe entities properties of three-dimensional space in the two-dimensional one of the othogonal planes. The solution proposed by the scientist consisted on the fact that the object position was described by a representation on two orthogonal planes. According

to this procedure, the object can assume any position with respect to the reference planes that describe the position of the object itself in space through a projection system. Through this coding system, the French mathematician has succeeded in eliminating any ambiguity in the passage from representation to reality and vice versa.
In this way a discreet method was developed in order to speed up operations to be carried out more objective and clearer the process of representation. Gaspard Monge was therefore able to codify the topic of parallel projections with his texts, transforming drawing into the graphic representation science. The method he proposed satisfied the need to represent actual and very accurate shapes and sizes that useful for manufacturing production [Docci, Migliari 1992, pp. 74-78].
The language proposed by descriptive geometry thus becomes a suitable candidate to play a fundamental role in the industrial production era.
With modernity, technical drawing is able to respond to the mechanization of cities needs which knew the introduction of architectural forms and spaces of new conception based on new materials such as iron, during industrial revolution. With this transformation, the size of the city changes together with the shape and relationship of buildings in the urban context, proposing new styles of urban representation. The use of the prefabricated iron beam soon became the symbol of a new architectural formalism that also extreme the value of the design as a necessary tool to return the idea of project ready to be realized in series. With the industrial era, architectural drawing was transformed from a conceptual and cognitive tool into a functional project for building production, which would then need to create precise rules and regulations to codify the language of design drawings [Bennicelli 2006, p. 265].
The design sector was in line with the needs of the time, highlighting the descriptive characteristics of a certain artifact as a whole, even if observed for significant parts and no longer privileging the individual parts, plan, elevation, section [Bennicelli 2006, p. 266].
In the modern era, architectural design has seen a wide use of axonometric as a communicative language of spatial communication, highlighting the volume and describing the components of an artifact through the exploded drawing.
Through these languages, the importance of interdisciplinarity is enhanced by highlighting the need to communicate different information about form, matter and technology in relation to levels of focus such as context, artifact and detail.
Beside the stylistic research characterized by formal purity, the aim of the design was to represent architectural and urbanistic complexity in two moments of the design phase. The first one was related to the idea identified by the sketch, while the other one was concerned to the design development through the systematic proposal of materials and construction technologies inspired by industrial production, looking for a new industrial aesthetic [Bennicelli 2006, p. 268].
The attempt to understand and describe the role of representation, not only as a tool for translating the mental idea into a graphic sign, but also as a place where the design idea is expressed as the highest expression of the architect's poetics. The spirit of the Modern Movement is then embodied and substantiated, examining the architectural drawing as a mental and cultural tool [Florio 2012, p. 12].
In this sense, drawing is conceived as a vehicle to transmit information, but above all as a possibility that it identifies itself with the purpose to be achieved [Melis 2016, p. 891].
In this context, the activity of reading a building of the existing architectural heritage using a sign or a technology need to concretize the image of the human thought of a certain artifact through the direct consultation of graphic documents produced in the time of the project activity (fig. 1).
The survey activity allows therefore developing representations of the reality that produce mental images of the artifact that can be materialized in the development of a virtual model information augmenting the detail degree from time to time (fig. 2).
In this context, Riccardo Antonini tried to formalism at this vision of drawing by introducing a formal theoretical model in which reality representation by the human being intrinsically produces a three-dimensional virtual world that is implemented through the mechanism of perception [Antonini 2004, pp. 54-61].
The mental images of reality and of its very representation produce a series of relationships that give life to the project. Thus, several definitions are available on it: the mental image representation of a person who

Fig. 1. North elevation, vertical and horizontal sections and the layout view of Torre Littoria, located in Turin. Fondo Melis de Villa, LSBC Politecnico di Torino.



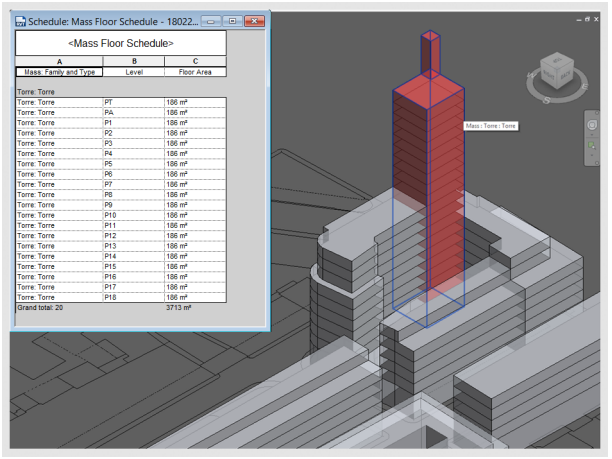


Fig. 2. Mass Axonometric view of Sant'Emanuele district with mass floor schedule (graphic elaboration by the author).

imagines the perception of an object as if it had already been developed and the representation of the project itself through the drawing activity. This operation has brought over time the real world closer to the virtual one by defining some differences between drawing and simulating the imagination, creating two areas such as the design-drawing/survey and that of Virtual Reality (VR) (fig. 3). Through object modelling and the materialization of the project image through informative 3D models, the two sectors are producing several interaction aimed at optimizing the construction process.
La comunicazione dell'idea progettuale può essere attuaTherefore, communicating the design idea can no longer be implemented only by means of a graphic sign on a surface, but also by processing a digital model.
This is enriched from time to time with information, generating different products including immersive visualization and graphic works, bringing the world of representation closer to the real one. In this way, representing the existing heritage occurs through the production of virtual models that transform traditional image of drawing as an instant that stops the flow of time [Dal Co 1989, p. 6], in a contemporary path that makes dynamic the reading of a building, through a communication language focused on the efficient data management through Information and Communication Technologies (ICTs).
In the era of digital transformation, representation is innovated with this language based on the creation of parameterized three-dimensional models in which heterogeneous information is brought together to generate possible scenarios. In this way, Drawing sector is revisited as a fundamental actor in the path that, from reality, passes through the mental images present in the formal conception of the represented object [Spallone 2012].

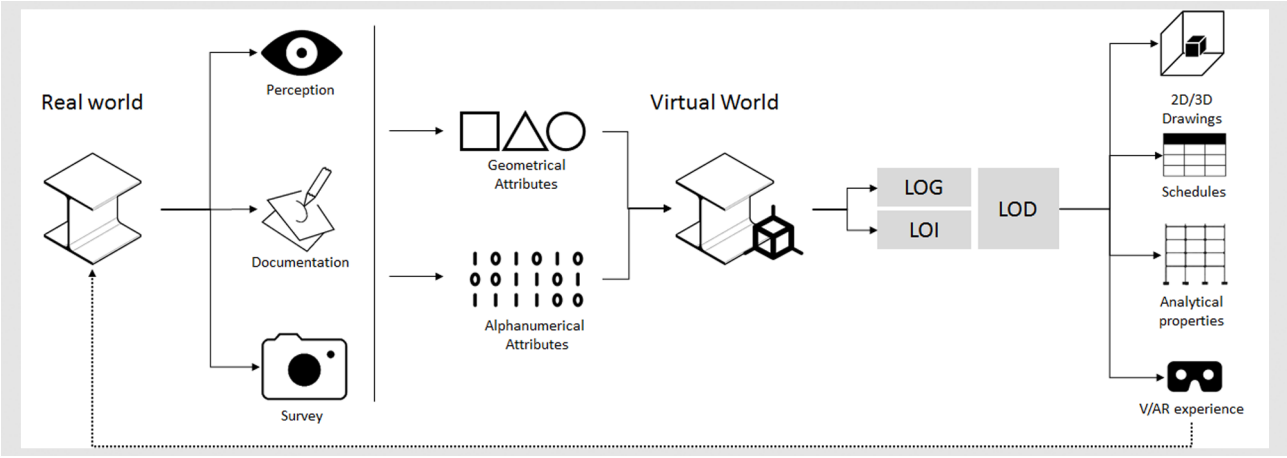
The role of digital technologies and information modeling

Traditionally, professionals have communicated their design content to the whole construction process developing a series of 2D and 3D graphic documents. This is associated with the concept of importance that underlines the value of direct consultation of these documents observed in their original materiality to disseminate knowledge of a built heritage.
Currently, Building Information Modelling (BIM) is innovating this procedure, focusing on the development of a shared graphical database that describes a large amount of information stored in 3D parametric objects including walls, floors, beams and analytical connections richer in data than simple sign-based drawings. Thus, digital information is considered the real added value because it favours the optimised data management which can also take place in a delocalised way, based on platforms that allow sharing of interdisciplinary knowledge. The collaboration between all the actors involved in the construction process takes place, adopting a working methodology based on common languages to transfer information and optimizing data management. Developing one or more databases facilitate the creation of data interactions, enhancing its uniqueness that can be filtered for different uses through interoperability. The information models can then be integrated by all professionals, adopting a shared protocol based on the creation of intelligent objects according defined exchange rules [Osello 2012, p. 61].
While traditional representation of built environment is characterized by two-dimensional products based on silent objects without any connection or relation between them, the development of 3D parametric models

describes reality with intelligent objects that are combined with each other to create a single database (fig. 4), containing the whole building data [Ciribini 2013, pp. 15-22].
This innovative methodology is based on the concept of worksharing among the different actors involved in a project activity that is identified as a specific moment in which each user tries to define an image of reality or of what he would like to achieve to satisfy a certain need. Thus, over time, informative models have improved their quality, thanks also to technological evolution, developing an important increase in performance of work. Taking into consideration the existing architectural heritage, the knowledge phase relating to a certain artifact, which can also be carried out by means of surveying activities, establishes a first image of the real world that can be traced through the production of digital or non-digital works. This activity is currently concretized through the elaboration of information models, simulation vehicles and the contracting of a resulting product or a process of the construction sector, through information contents of graphic, alphanumeric and multimedia type [UNI 11337-1:2017, p. 11]. By processing object-oriented parametric models, representation is enhanced including information as an added value in graphic design.

Architectural space is therefore described by solid components and spaces reproduced in various simulations that can be developed thanks to computers that have the ability to connect real world with the digital one. With information models, the artifact representation no longer falls within the usual orthogonal 2D projections or axonometric and perspective views, but in the reproduction of something that exists or need to developed subsequently.
In this sense, the idea of drawing was not modified according to the mechanical or electronic tools, but it has been enhanced continuing to hold the fundamental role of communicative language to optimize representation of both reality and project.
The elaboration of simulation models, offers today the opportunity to optimize the management of data, making them consistent with each other with the opportunity to narrow the distance between real and the virtual world. Simulation images of both real and project can therefore take place starting from models that can evolve over time, according to the objectives and uses that have been drawn up or requested.
Thus, the starting point for these information models is the definition of geometrical (LOG) and alphanumerical (LOI) detail levels for each object that

Fig. 3. Conceptual scheme of representation process from Real to Virtual World



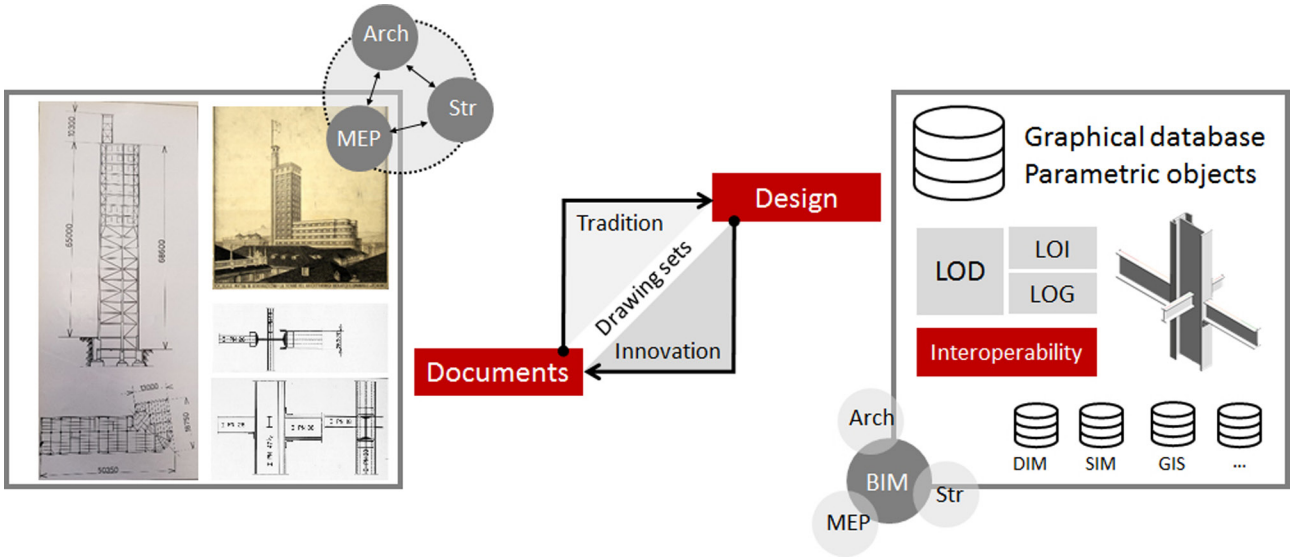


Fig. 4. Methodological scheme for comparing traditional and innovative approach in the construction industry.

must be related to the totality of the model through its attributes, to be increased subsequently. Taking into account the existing building heritage, the Level of Detail (LOD) of the objects needs to regard objective information, related to reality, with the aim of assimilating and extrapolating data for future planning or management [Pavan 2017, pp. 14-28].
The simulation of real building components with virtual objects libraries allows to describe a certain object in different ways by computer in terms of attributes and geometries through schedules, 2D and 3D views, bringing the world of representation closer to reality.
For this reason, information management related to the creation of a parametric model starts from the analysis of historical documents, the reading of the building characteristics through freehand sketch of the artifact and multimedia documentation. then, the definition of the geometric and alphanumeric attributes are the starting point for elaborating the BIM model composed by objects with a proper LOG and LOI for the declination of the relative LOD. Some of the information inserted in the objects can still be linked to traditional representation means, while others refer to structural analysis or immersive visualization through Virtual/Augmented Reality (V/AR).

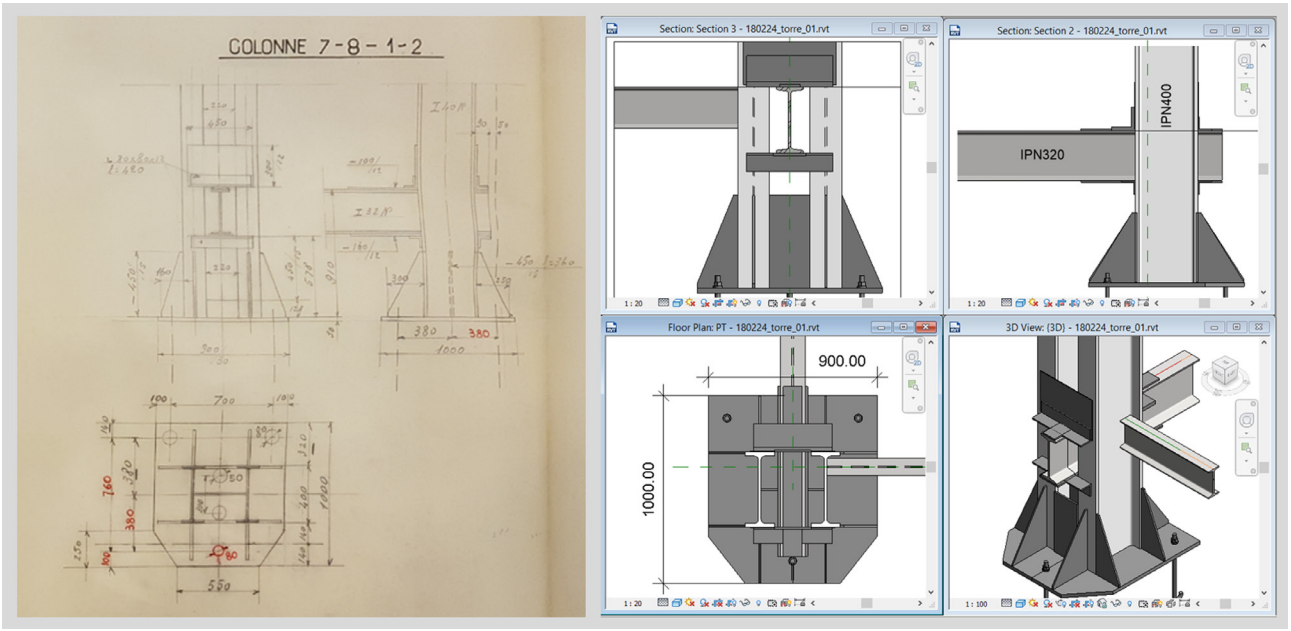
Methodology

The attempt to understand how the role of representation is fundamental in order to make effective the process that translates the mental idea into an information model is examined in this contribution by analysing the Torre Littoria in Turin, a steel frame building, built in the 1930s. At that time, the image of the capital of Savoy needed to be renewed driven by the fascist current that clearly emphasized its requirements also in urban and architectural terms. The development of an architectural national style rooted in classicism, lead to the introduction of innovations in the use of building materials and in the site management, which was to reflect the production lines of factories.
The adoption of the welded metal structure is certainly one of the most important innovations proposed by the designers Armando Melis de Villa

and Giovanni Bernocco. The main body consists of ten floors above ground which become twenty in the tower with an overall height of 85 meters. The tower is placed in adherence to the body of the building to be preserved in Castello Square [Moglia 1995, p. 117].
In a Casabella article of 1938, the load-bearing structure of the tower is included among the examples of constructions with a metal cage frame that is fully welded. The columns are uniformly made up of double-T beams coupled and connected by welded flat irons placed at a distance of about one meter. The pillars extend every two floors and the main beams are perpendicular to the facades to provide stable frames with the columns, ensuring transversal stability of the building. The use of metal framing facilitated and speeded up the building construction, which is made up of various standardized components that can be assembled on site by a few workers [Fava 1938, p. 40].

The consultation of project documents related to the tower took place both at the national archive of Turin (AST) and the Melis de Villa Fund, located at Politecnico di Torino. This archival research has favoured the creation of the mental image of the tower, which has triggered a process of research about geometric and alphanumeric attributes that characterize the building components of the metal structure.
Therefore, the information model was drawn up focusing on certain construction details such as the basement of the columns (fig. 5), the joint between columns of different levels and also the beams – columns connection.
The modeling process started from the main components analysis of the metal framework, focusing on BIM objects loading into a BIM authoring platform, such as Autodesk Revit. The ability to reproduce construction details by creating a series of objects that describe each part facilitated the handling of problems related to detailed modelling scale. Each con-

Fig. 5. Comparison between an archival document (Archivio SNOS, Torino) and a BIM costruction detail of a column basement.

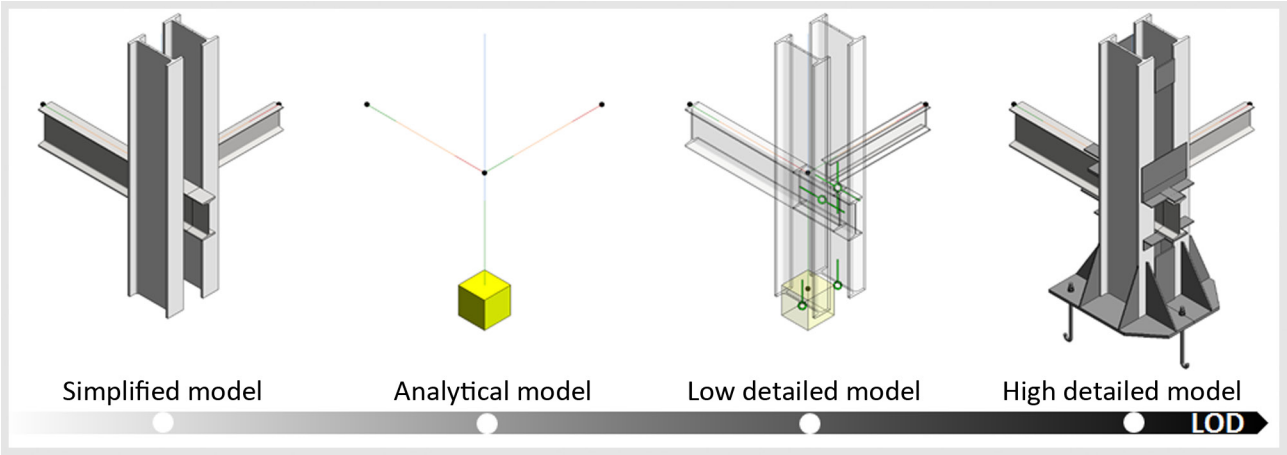


struction detail is described according to the architectural components visible in historical documents, taking into account data relating to shape, quantity, size, position, assembly details and characteristics of the manufacturing world.
In addition to the physical characteristics, the proposed details also describe the structural characteristics, geometric, material properties and are able to describe structure loads.
This information generates an analytical system of rods and nodes. This virtual reproduction offers the chance to use BIM dataset also for specific structural analysis and simulation applications. The physical model representation is therefore related to the analytical model, even if the latter can be managed independently. In particular, although the object describing the physical column consists of two IPN beams connected with battens, the related analytical column have to be modified to uniquely describe the rod that must represent properties used for structural simulation.

Results

Developing objects able to represent multiple information of various disciplines has allowed a progressive gap reduction among virtual and real world. In this way, this digital development can offer a variety of artifact reproductions that can be used for the management of existing architectural heritage.
This goal required considerable effort in modeling, strictly related to the hardware capabilities of applications available currently on the market. The development of information models with a large amount of geometric and alphanumeric information can reduce the computer performance and make the modelling process complex and laborious. The evaluation of suitable LOG/LOI was fundamental for the achievement model objectives and uses, which in this case were focused on the ability to reproduce a construction detail in virtual world (fig. 6).
The proposed solution in this contribution aims to demonstrate how information models can achieve high levels of geometric accuracy, describing a certain object with heterogeneous characteristics.
However, a number of issues have been identified concerning the standardization of objects used to represent digital models of existing buildings.
These considerations highlight the potentiality offered by BIM methodology based on the generation of a single information model composed of a series of components that describe a construction node. The detail

Fig. 6. Representation of the BIM construction detail, related to a progressive LOD.



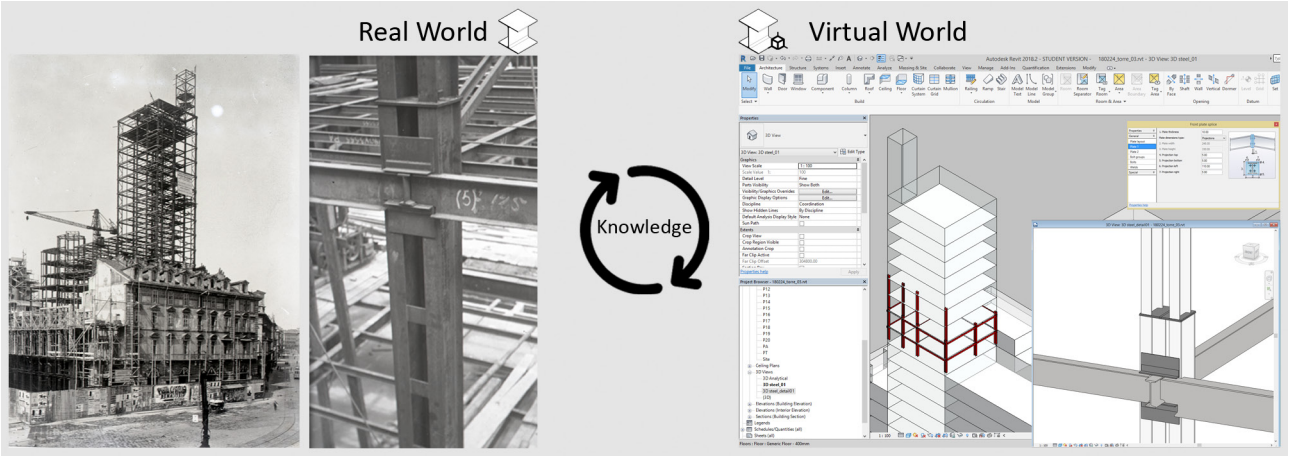


Fig. 7. Comparison of archival sources describing the real world (Fondo Melis de Villa, LSBC Politecnico di Torino) with the informative model.

proposed as a digital prototype of reality is characterized by shape, relative information and its analytical capabilities for a possible use in a specific structural analysis application.
The tests carried out show some data losses such as for structural connections are not kept during the interoperable process, thus making data exchange not error-free. Thus, importing the model into specific software does not retain all the assigned features in the native environment causing data loss. This result must therefore raise questions about rules that must be followed for the development of objects that describe the construction nodes both from architectural and structural point of view.
Through the creation of some structural details related to Torre Littoria, the investigated process outlined can be assimilated to an iterative process in which it is possible to improve the idea of the perceived environment with digital model. For this reason, the fill in data on each single objects becomes fundamental to transform itself into information through various interactions between them in the modelling environment. Clearly, BIM methodology innovates the traditional approach of representing reality based on the creation of a series of technical drawings that illustrate the project (fig.7). Starting from a unique model, in fact, it is possible to get the information related to each other, avoiding waste of time and costs, improving the knowledge of the built heritage.
The virtual reconstruction of an artefact can therefore be considered the starting point for the creation of a digital platform based on various heterogeneous databases that can be correlated to describe, as an example urban space, energy distribution networks and territory.

Conclusion

The comparison between traditional and innovative technologies, expressed in this contribution, enhances the role of representation within the building process that is constantly evolving through to ICTs.
The perception of existing buildings can therefore be concretized in the elaboration of an informative model that is an interpretation characterized by a series of operations of reading and synthesis through the language of the parametric 3D modeling. In conclusion, the representation becomes an expression of a past not directly observable, but perceptible through the interpretation of historical and multimedia sources using innovation technology.

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