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THE ARCHAEOBIM METHOD AND THE ROLE OF DIGITAL MODELS IN ARCHAEOLOGY

1. BIM, HBIM AND ARCHAEOBIM

The contemporary building industry is influenced by many important methodological changes, almost aimed at the satisfaction of increasingly persistent regulatory, economic and qualitative requirements. Collaborative strategies taking advantage of database frameworks, just like the Building Information Modeling (BIM), are main drivers of these transitions, whose paradigms of interoperability and interdisciplinary workflows can today fit also the archaeological field. Its intrinsic peculiarities already encompass the knowledge belonging to many research fields, even if they are not often sharing the same tools or procedures.

The wider and wider adoption of BIM among disciplines, which interact with each other through digital models enriched by information, suggests the application of a similar process to the archaeological investigations (see among others AZKARATE 2002; SCIANNA *et al.* 2015; BOSCO *et al.* 2018). In a consolidated BIM process in fact, different disciplines (architectural, constructive, structural, managerial, etc.) converge into models authored by the aggregation of “smart” elements, endowed with a sort of self-consciousness of their geometric and behavioural values, able to collect data pertaining to many different activities. Recently, the advantages of BIM application have also been appreciated dealing with historic buildings, due to models dedicated to the documentation of the monumental heritage: the HBIM acronym (Historic Building Information Modeling) was introduced specifically for this context (MURPHY, MCGOVERN, PAVIA 2011).

However, in general terms, the HBIM is an approach based on the existing domain, documented by high resolution surveys (by terrestrial laser scanning or digital photogrammetry) and decomposed into constituent elements encoded in semantic categories and then aggregated into parametric models (BOEYKENS, HIMPE, MARTENS 2012). It is basically a comparison between the registered point cloud dataset and a library of digital objects already prepared to replicate the reality more or less faithfully, with parametric components superimposed to the survey in order to find similarities and proportions (CHEVRIER *et al.* 2010). The analysis and aggregation of many information related to consolidate historical scenarios gave a certain scientific credibility to HBIM, but it is not possible to systematically extend its benefits to archaeology, where evidences are not always well preserved and buildings are often no more existing. In order to better distinguish this scenario from

the peculiar features of HBIM that, as mentioned, relies on different premises, a slightly original process was developed in recent years, described with the term ArchaeoBIM to better underline the common BIM matrix but declining the methodology to the particular field of the archaeological reconstruction.

S.G., A.G.

2. BIM IN ARCHAEOLOGY

The heuristic path of Virtual Archaeology as an autonomous discipline has been limited, so far, by its restrictive consideration as a simple means of visual restitution (GARAGNANI *et al.* in press). It is no coincidence that the principles of the main Charters formulated by the international scientific community (*London Charter 2009* and *Seville Charter 2011*) have focused precisely on the combination of restitution/visualization, not considering an important aspect that was the key element at the time of the conception of the discipline, i.e. interactivity (REILLY 1991).

Recalling this very first theoretical purpose, we can claim that the introduction of BIM in Virtual Archaeology allows scholars to work more effectively on digital models. Indeed, BIM is not simply a visualization method of a lost past (impossible to reconstruct in its entirety). It is also, and above all, a cognitive process and an interactive environment where research, conservation and dissemination are synthesized.

2.1 *The digital life of the archaeological record*

The archaeological analysis has always placed the material record in the foreground, developing models and theories from its descriptions and analyses. It is therefore the witness of a more complex reality, lost forever. Because of its importance, each artifact has more than one life, starting as an object of use and finishing as archaeological record (LUCAS 2012). The ArchaeoBIM method, which focuses on no more existing buildings, aims precisely at a better knowledge of lost heritage, through the digital reconstruction of the past with the available information acquired from the archaeological context. If we look at the architectural structures as complex artifacts, we could say that the ArchaeoBIM offers a new digital life to them.

However, this method must not be interpreted as an attempt to digitally recreate a lost phase in the life cycle of an artefact. Indeed, there would be no end to the attempt to reconstruct a reality that is unattainable in its entirety. We must be aware that the process is possible, but only at different degrees of verisimilitude. Therefore, it must be affirmed from now on that a fundamental point of this new method is not the mere evocation of the past, but the validation of the digital result through a replicable process which has at its base the collection of all available information. The method allows

for checking and verifying the various possible responses of a reconstructed model to environmental stimuli in a virtual eco-system as close as possible to the most likely actual ancient one.

2.2 Digital models as tools for research, conservation, dissemination

The ArchaeoBIM is thus a method of digital reconstruction, which legitimately answers to the theoretical questions that have been asked since the birth and during the development of Virtual Archaeology as an autonomous discipline. Moreover, this method guarantees the possibility of integrating research with conservation and dissemination. In fact, the digital model expresses itself as an articulated container of information, which we could interpret as a three-dimensional database. It can host not only the data of its own heuristic process and information regarding architectural and physical aspects, but also any further information, fostering the process of conservation. Digital models could then serve as communication tool at the service of museums and archaeological parks.

These aims are possible only if each new and fertile method we develop is integrated into articulated research projects, because only these can offer a solid methodological framework and constitute a means with multiple objectives. Coming to this, an example of this approach is the Kainua Project, funded by the Italian Ministry of Education, University and Research (FIR 2013), within which the ArchaeoBIM method has been developed. The project aimed at the realization of the digital model of an entire Etruscan city (i.e. *Kainua*-Marzabotto, near Bologna) on the basis of a rigorous philology and according to the theoretical bases of Virtual Archaeology (GAUCCI 2017). The objectives underlying the project respond to the three cornerstones of conservation, research and dissemination, arriving in fact at the collection of all available data; the simulation and analysis of the digitally reconstructed environment; the development of products usable during site visits and inside the Museum (ANZALONE, GAUCCI 2019).

A.G.

3. METHODOLOGICAL APPROACH: THE PROCESS AND THE DIGITAL MODEL

3.1 Semantics and meanings

Into an ArchaeoBIM semantic model individual elements retain the memory of their associated multidisciplinary information as well as ordinary BIM models, but they also include data related to excavations, materials, building technologies and all those elements that can be related through a database dedicated to various disciplines based on defined ontologies. The ArchaeoBIM process is based mainly on the semantic and functional synthesis of architectural components replicated in the digital domain: the meaning of those digital elements can be compared to linguistics. While the syntax, in fact,

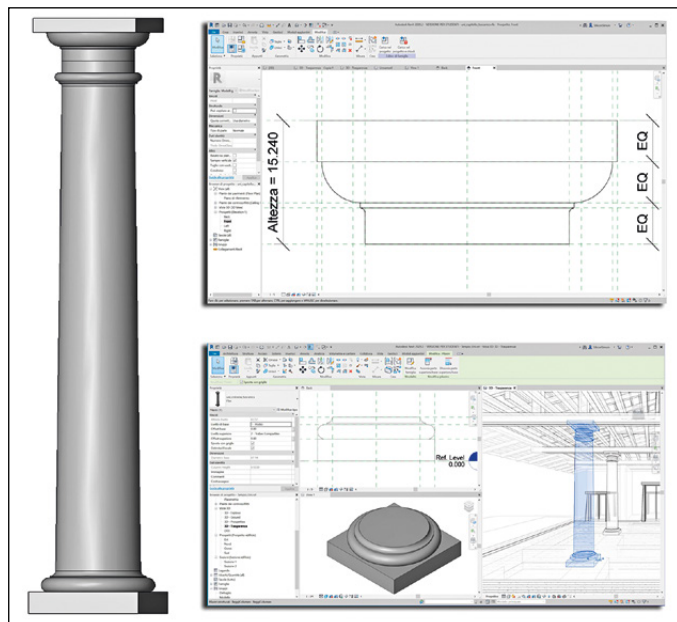


Fig. 1 – A simple Tuscanic column ruled by geometric parameters is linked to information (i.e. material, structural function, building phase, abstract constraints, etc.) used to mimic its behaviours of bearing loads of trusses on top of it.

is the study of letters' combinations, semantics is the study of the meaning they get in forming meaningful words: syntax and semantics are part of the grammar, which establishes the rules governing the composition. Like letters and words, architectural elements respect a more general grammar, which expresses their order and function.

An ArchaeoBIM model allows for the semantic reconstruction of components by specifying their role both from a compositional point of view and from a functional perspective. In order to acquire all the information necessary to characterize them, many different disciplines must collaborate in defining the morphology, the used material, the layering technique, the resistance to stress, the durability of elements and so forth (Fig. 1).

3.2 Data survey and digital acquisition from heterogeneous data sources

The semantic ArchaeoBIM model is a sort of visual index for more extensive content, from measured distances (especially point clouds; TANG *et al.* 2011) to constructive notes, from archival sheets to literature works, useful in collecting different sources for many purposes. All the elements pertaining to



Fig. 2 – The Kainua Project within the Cultural Itineraries of the Virtual Museum of Archaeological Computing (<http://archaeologicalcomputing.cnr.it/itineraries/projects/the-kainua-project-a-challenge-in-complexity/>).

a specific site or monumental building can be replicated into a digital model, as experienced at first in the Kainua Project (Fig. 2), where many buildings were studied beginning from the ArchaeoBIM replica of the *Uni's* Temple (GARAGNANI, GAUCCI, GOVI 2016).

3.3 *Authoring the ArchaeoBIM model*

The digital environment chosen to replicate the case study context was Autodesk Revit, a software specifically designed for contemporary buildings design, whose all components are structured into a precise “family” hierarchy (Fig. 3), connected to a semantic database. Families are sort of exclusive

containers for the different types of objects that interact among them according to several rules, depending on their level of importance, and hardwired into the parametrical engine of the software (FAI *et al.* 2011). Investigated components can be linked to knowledge-based systems, which guide the construction of a virtual building, as it were, really built in the real world, considering materials stress, building technologies and then known building techniques. This way, the authoring of the digital model precisely follows the real building process, with a first check for constructive solutions that is undergoing while modeling. The ending result, depending on the level of detail achieved, can replicate the construction up to the minute detail, validating simulations and possible reconstructions in a philological way.

3.4 Simulations and validations

Presented case studies were exemplar in testing the ArchaeoBIM process: the feasibility of a construction can be validated with sufficient certainty. The digital model expresses the most plausible dimensions of building elements in order, for example, to bear static loads: the deciduous oak used in the temple of *Uni* was carefully studied and replicated, following this approach, to consider its orthotropic behaviours towards deformability, with a density estimated to be 670 kg/m^3 , while about 3000 flat and semi-cylindrical tiles were probably used to cover the roof slopes. While some simulations were prepared to compare different materials and building sequences, the virtual reconstruction of the temple of *Uni* was generated considering the effective structural performance of the building, using dedicated analysis programs.

S.G.

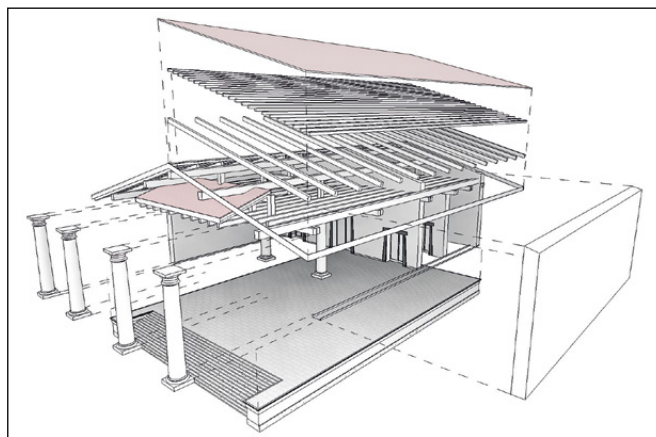


Fig. 3 – A Revit family is a category whose elements are digital representations of real building components (e.g. columns, roofs and walls).

4. FUTURE PERSPECTIVES

The BIM process (long before the BIM software applications) represents a paradigm shift for the architectural documentation and investigation of new buildings, while HBIM has proved to be effective dealing with existing ones: it really is a digital cross-language for architects, engineers, historians and technicians, able to let them share specific knowledge in a coherent and referenced way. However, archaeology often needs to reconstruct ancient buildings or monumental sites in order to study and preserve the Cultural Heritage they represent. That is why ArchaeoBIM stands as a proper methodology that keeps the advantages of BIM-based modeling applying them to no more existing architectural domains that cannot be directly investigated, connecting all the knowledge to specific databases and leading to an authentic interdisciplinary approach.

We should therefore change the perspective: the reconstruction not for the artistic quality of the monument, but for its intrinsic value as an archaeological asset, as a “virtual record”. In our view, the newborn record should be released from the materiality of the artifact it originated from, assuming its own autonomy of existence. Only conquering this autonomy, we will be able to grasp the potential of digital models as fundamental tools for the knowledge and preservation of our past.

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ABSTRACT

The paper deals with the development of a novel methodology, named ArchaeoBIM, aimed at the creation of digital models representing no longer existing buildings, starting from the available information collected from the archaeological contexts. The process is inferred by the Building Information Modeling used in the contemporary building industry, where different disciplines converge into digital models. The achieved models meet some of the cutting-edge issues of the Virtual Archaeology, i.e. validation, management of data, simulation. These products answer to important needs in the fields of research, conservation and dissemination and could be considered as archaeological records themselves.