From the Shelf to the Map, from the Map to the Information Model and Back: the Archivio Porcheddu at the Politecnico di Torino

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Abstract

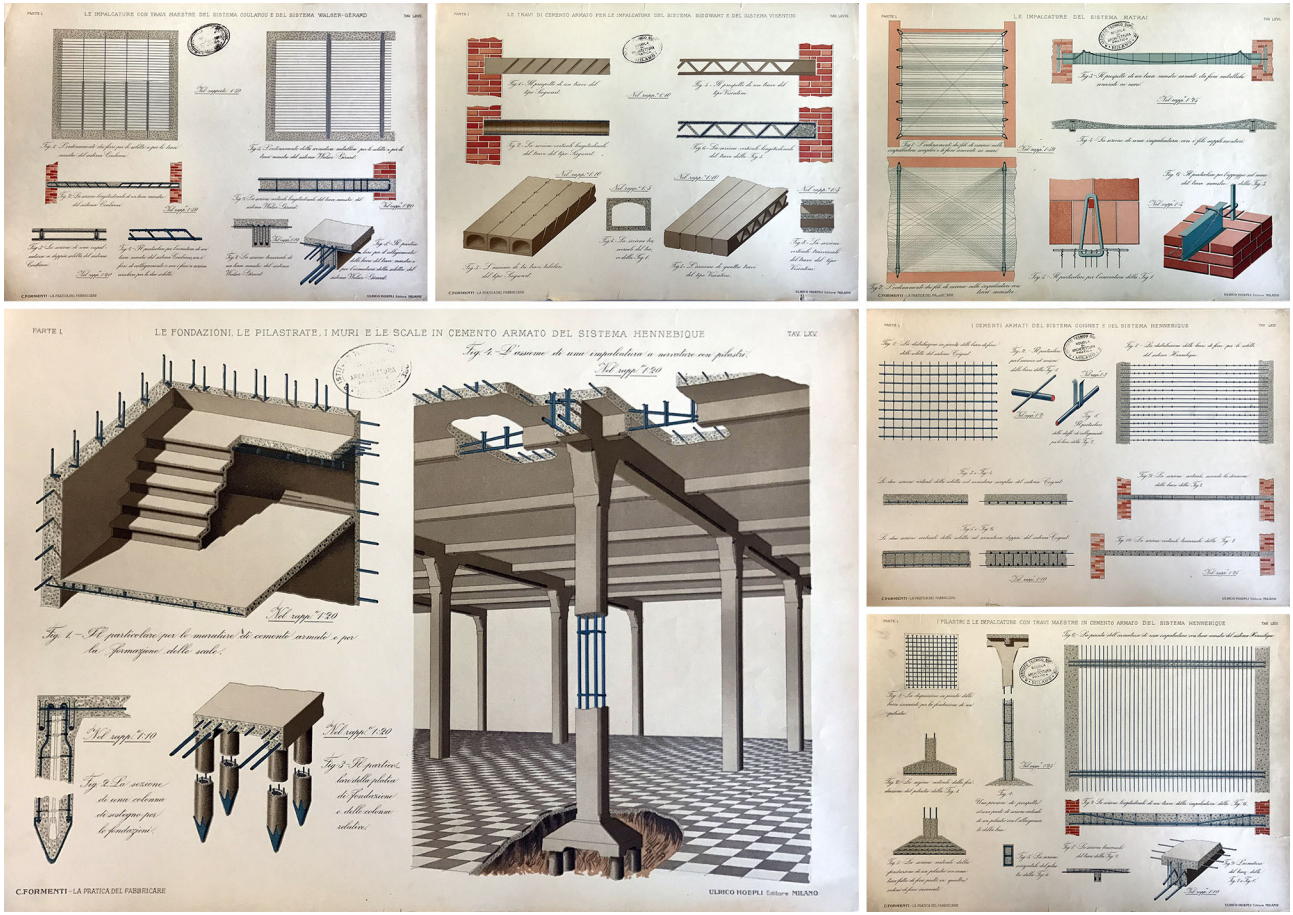
The Politecnico di Torino has undertaken actions to promote and disseminate its historical archival heritage as a unitary system of technical knowledge and information. The critical use of dedicated management methodologies and information technologies is the cornerstone for the enhancement of its repositories. The contribution illustrates the preparation of a web-based distributed information system that links together the apparatus of the Archivio G.A. Porcheddu in the period 1894 to 1994. Porcheddu in the period 1894 to1927 –Agent and General Concessionaire for Upper Italy of the system patented by François Hennebique– kept at the Department of Structural, Geotechnical and Builiding Engineering of the Politecnico di Torino. These heritages are rich in conceptual elements, brought to life by specially designed graphic supports, which effectively exploit the performance of digital technologies and restore value to the most recent studies on the City through more efficient processes of sharing.

Keywords: Archivio G. A. Porcheddu, Hennebique System, reinforced concrete collections and documentation, 3Dweb.

The cultural context and research activities

The development of the practice and graphic codification of reinforced concrete projects has been the subject of studies presented on several occasions for scientific discussion, including the cultural context within which this business archive, which is very interesting for the history of civil engineering, was formed.
As an example, graphic boards complement the volume of polychrome lithographs and accompany the 1909 re-edition of the 1893 *La pratica del fabbricare* manual by Carlo Formenti (professor at the Regio Istituto Tecnico di Milano), presenting some of the construction systems patented at the time: the reinforced cement of the Coignet system and the Hennebique system; the pillars and scaffolding with reinforced concrete main beams of the Hennebique system; the foundations, pillars, walls and stairs in reinforced concrete of the Hennebique system; the scaffolding of the Matrai system; the scaffolding with main beams of the Coularou system and the Walser-Gérard system; the reinforced concrete beams for scaffolding of the Siegwart system and the Visentini system (fig. 1).
The advent of reinforced concrete and its first applications constituted a field of research experience for the discipline of Drawing, which in some occasions of scientific comparison on the subject the Authors [Novello, Bocconcino 2018a] have defined as a "field of graphic experimentalism": maps and drawings that in the first projects anticipated that formal codifica-

Fig. 1. Concretes and reinforced cements in different construction systems [Formenti 1909].



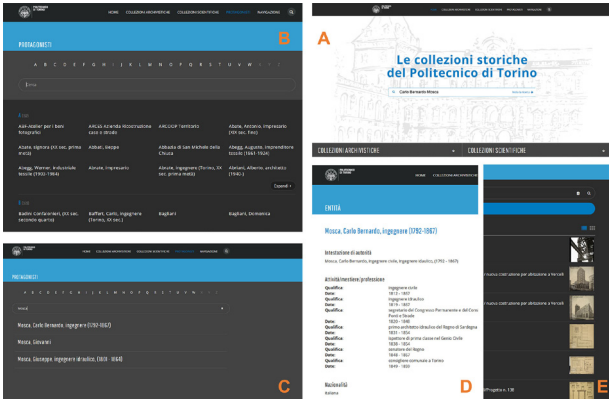
tion that was the matrix of representations that over time, and concerning the development of techniques, have evolved up to the current graphic standards. The Authors [Novello, Bocconcino 2020] have been investigating those expressive forms for a long time, largely based on the study of the vast *corpus* of documentary and iconographic sources of the Archivio G.A. Porcheddu [1], stored in the Department of Structural, Geotechnical and Building Engineering (DISEG) [2]. buildings, and their components.
The contribution shares the experience of an Italian university on the theme of diffusion, seen by the Politecnico di Torino as a structural aim of the management policies of its historical repertoires: *archivi vivendi*, which open up within the panoramas of technical knowledge to validate vocations and exclude dangerously risky interventions [Novello, Bocconcino 2019].
The complexity of the operation that we intend to bring to light at DISEG, resulting from the constant work of the Departmental Commission for Museum and Archival Heritage (coordinated by Pina Novello until November 2020), in line with the guidelines laid down by the Commission for the Enhancement of the Library, Archival and Museum Heritage of the Politecnico di Torino (coordinated by Professor Sergio Pace), lies in the fact that sharing and disseminating the results of the research cannot merely follow the care given to the dissemination of documentary, book and iconographic materials (fig. 2) [Novello, Bocconcino 2018b].

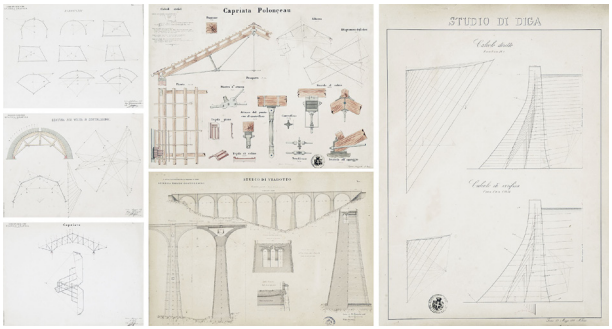
Fields of experimentation: Archivio Porcheddu at the Politecnico di Torino

Among the archives of the Politecnico di Torino endowed with DISEG, the Mosca and Porcheddu archives, scientifically edited by Pina Novello, Maurizio Marco Bocconcino and Paolo Piantanida, constitute a significant part of the entire patrimony preserved. To these fonds is linked an important repertory of works produced by the student engineers of the Regia Scuola di Applicazione per gli Ingegneri in Torino (files of reports, calculations and drawings) (fig. 3) and a large collection of construction models, historical models used between 1865 and the end of the 19th century as teaching aids; the cultural richness of this repertory

Fig. 2. Politecnico di Torino - Archival and Scientific Collections Portal (Le collezioni storiche del Politecnico di Torino: <https://collezionistoriche.polito.it/>, accessed 1 March 2022).

Fig. 3. Summary of the theoretical and practical activities of the art of manufacturing learned by the students (source: Politecnico di Torino, Allievi della Regia Scuola di Applicazione per gli Ingegneri, 1878-1897).





has prompted many studies displayed for the exhibition *L'arte di fabbricare - Giovanni Curioni and the birth of Construction Science* housed on the premises and accessible virtually [3].
The corpus of documentary and iconographic sources in the Porcheddu Archive is a precious heritage that is indispensable for investigating and understanding the birth and spread of reinforced concrete technology in design and construction practice. A distilled synthesis of the extensive iconographic apparatus preserved in the archive, which can be explored by using multiple thematic filters within an interesting and varied wealth, the applications developed lend themselves to being integrated to make those comparisons that are necessary to improve the understanding of a work and can therefore be used to support design choices for qualified reuse.
Finally, numerous studies have analysed the advent of reinforced concrete as a highly innovative construction technology through critical reviews and specialised in-depth studies, presenting different disciplinary approaches, mostly attributable to researchers from areas other than that of Drawing to which the authors belong [Albenga 1946; Gabetti 1955; Iori 2001]. The contribution of Nelva and Signorelli [1990] is very significant and accurate.

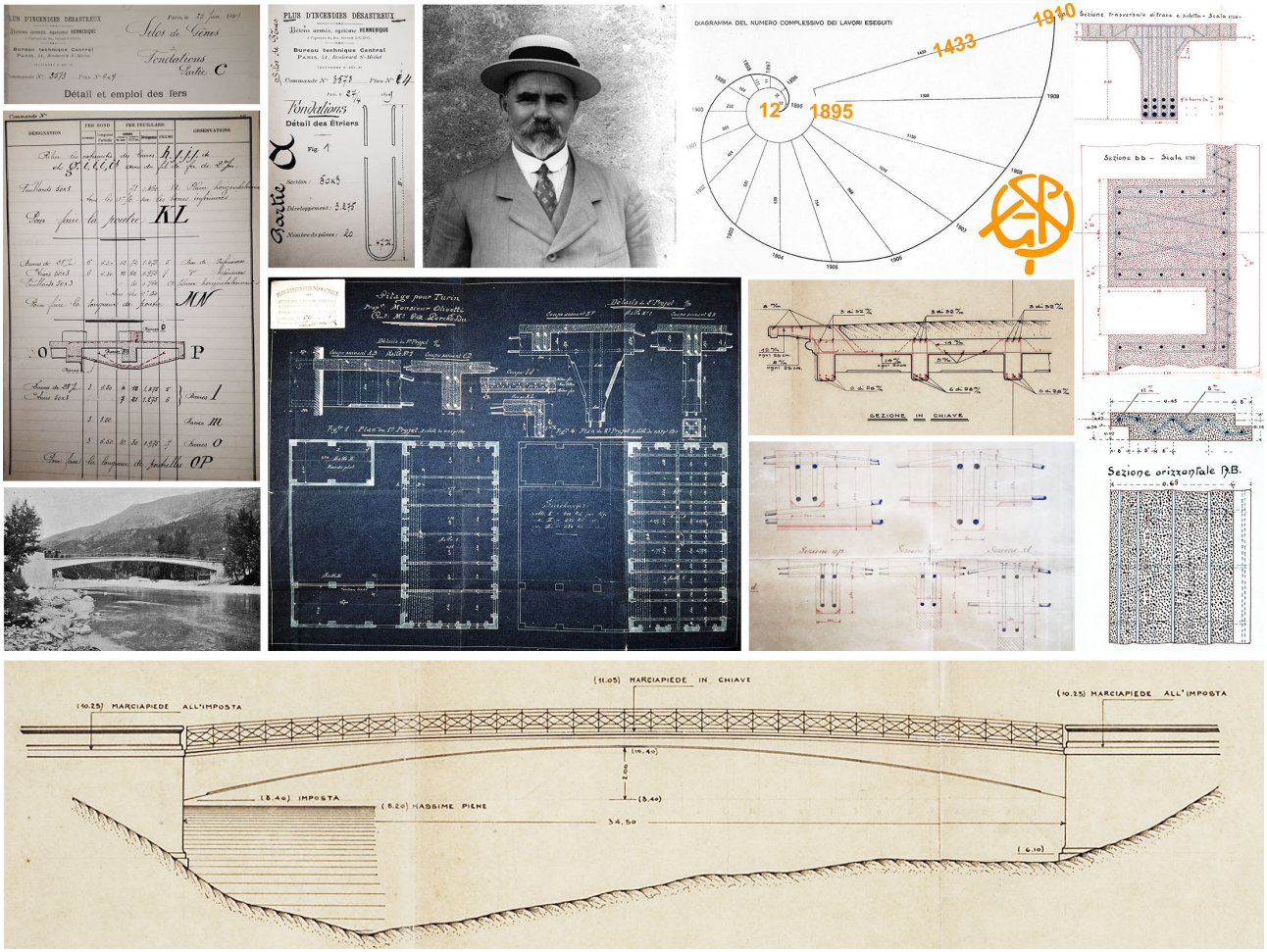
Graphic experimentation in reinforced concrete design

The documentation belonging to the Archive presents drawings aimed at executive and construction design, drawings developed within a workflow of a construction company specialised in an avant-garde field linked to international environments, intending to realise works that were also very demanding from the point of view of the construction site. If we want to dwell on the methods of representation used in the drawings, it is possible to note [Novello, Bocconcino, Donato 2017] a specification of information from the general to the particular, wherein the general plans the dimensions of the formwork and the arrangement and size of the reinforcement rods are defined; the introduction of a graphic convention for the floors, characterised by main beams and orthogonal ribs, which represents the soffit as reflected in a mirror placed below the floor, in French *plan vu en dessous*, and which is a convention that is still current; the cross-sections of the general plans turned over on-site, coordinating the views and modifying the scales of representation, according to the level of detail required; the partial sections on a larger scale, where the irons are extended for a stretch beyond the outline of the beam or column and hatched in the parts not in view.
Other interesting themes are the symbols of the sectioned conglomerate, which are replaced by simple contour lines; the irons, including the tie stirrups, which are represented with a continuous line; the measurements transcribed utilizing quotas placed in series, differentiated in the units of measurement, according to the element dimensioned: metres and centimetres for dimensioning and main and secondary modularity, millimetres for reinforcement. Again, in the first drawings, the colour was used to highlight the reinforcements. Later on, the need for multiple reproductions dictated the abandonment of colour and favoured simplified and conventional schematisation, with the increasingly frequent inclusion of textual, tabular and numerical annotations; as the complexity of the works increased, the structural component was represented in its own right, to better describe it and facilitate work on the site (fig. 4).
It is important to underline that the opportunity of direct consultation of the documents in the Archive allows an analytical evaluation of the permanence, invention or variation of the graphic codes used, highlighting the recurrence or predilection for certain systems of representation more suitable for the corresponding technical-descriptive purposes: overall and detail drawings, quoted at different scales (from 1:100 for plans and overall drawings to 1:25 - 1:10 for detail drawings), dense writing and cross-references, orthogonal projections, a large number of sections, axonometric projections and axonometric cross sections, and finally some perspectives dedicated to spatial articulation or to describe specific lighting performances.

A challenge: to disseminate and communicate through light and widespread systems, from the shelf to the map

One part of the experiments carried out on DISEG's heritage was the study of the methods used to proc-

Fig. 4. Variety and specification of codes and graphic techniques in the design of civil works (source: Archivio Porcheddu, DISEG).



ess data and information, intending to highlight the expressive and communicative potential of the archives' documents and of restoring it, in a simple yet effective way, with the help of digital processing made possible by information technology [Novello, Bocconcino 2006].
The paper material belonging to the archive is of various consistencies and formats. In particular, about consistency, some documents are vulnerable and deteriorating over time concerning media and transcripts that are losing their potential and informative quality.
Specifically, the information and computer system set up, on an alphanumeric and geographic basis, ties together practices and contents through two possible paths of in-depth analysis and information potential, explored to understand the advantages and criticalities to the composition of the documentary apparatus and the relative representation techniques used for the construction project of works carried out in Turin in the period 1894-1927.
The first path, which is extremely analytical and therefore more burdensome in terms of the resources and time involved, catalogues each paper document of the individual file, i.e. both the informative and content aspects, unfiltered by interpretations and extractions, digitally acquired with high graphic resolution to be correctly interpreted in all its parts. The second path, more synthetic and agile, was instead directed towards the detailed acquisition of alphanumeric data of the individual files, according to the same scheme operated on the first level of detail, but limiting itself to the digital acquisition of only those documentary elements considered significant, delegating to a subsequent phase the complete digital archiving. These digital selections were associated with information relating to the consistency of the file about specific categories, such as the number and consistency of documents relating to technical and special reports and types of graphic representation. In this more expeditious way, the user, even though not having access to the entire digital heritage of the "folders" still has the data relating to the size of the documentation and can consider whether to proceed further in the consultation and request direct viewing of the material.
Digital preservation is being carried out in distinct phases (fig. 5):
- the capillary activity of document registration through scanner or photographic acquisition, with a long-term time horizon;
- association to each document of all significant data;
- geographic localisation of all files within a geographic information system;
- expeditious recognition with the selection of some documents extracted from individual files and recording of the relevant data;
- registration of the main data and consistency of each file associated with an intervention;
- elaboration of schematic information model derived from archival documentary sources;
- association in the BIM environment and web environment of the documentary sources;
- field photographic surveys on opensource web gis;
- structure from motion from photographic surveys;
- cloud to bim and cloud to web and association of document sources.

In addition to the *corpus* of paper documents, there is also a large apparatus of photographic prints of construction activities that cannot be directly traced back to the specific files and for which the connection must be made by deducing the individual attributions from the images.

Docks Dora in Turin: from map to model

The proposed case study is part of the collection of the architectural-environmental identities of the city of Turin of a particular historical period, that of the advent of reinforced concrete on which we have previously focused: the Torino Docks, known as Docks Dora (fig. 6).
The methodology developed is based on the desire to create an integrated information system where it is possible to manage the data that will vary over time, and which will describe and bear witness to the changes to which the property is subject, based on the definition and integration of four main strategies:
- the collection and systematization of archival sources;
- the collection and systematization of direct or indirect survey data on the property;
- modelling of the asset: analysis of the possible models that can be created, focusing on their purpose and usefulness, on the users who will be able to use them and on the work environment in which they will be able to interrogate them;

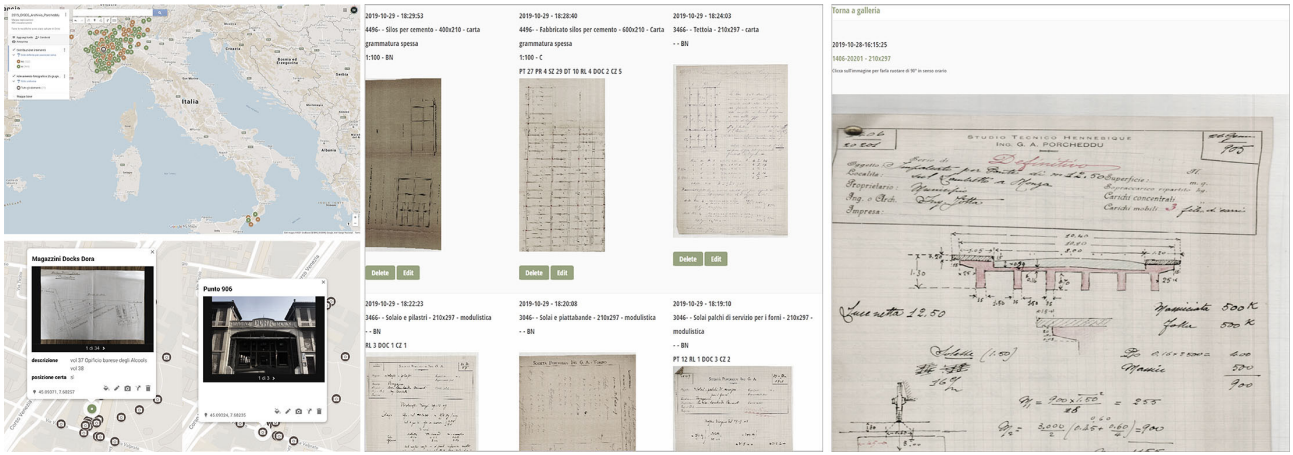


Fig. 5. Map in shared environment. Documentary materials associated with location. Georeferenced works about 900 out of 2,600 (source: extranet mmb-polito.info, user and password needed, accessed 1 March 2022).

- the communication and dissemination of the information system: with a careful analysis of the users who will have access to the operating system, the working environment in which it will be possible to consult and query the system and the type of communication to be used.

The information system has collected iconographic and documentary material in addition to the primary source constituted by the Porcheddu Archive, coming from the archival heritage of the city of Turin (fig. 7): the State Archive - AST; the Historical Archive of the City of Turin - ASCT and the Building Archive of the City of Turin - AECT.

The data collected were digitised and classified according to the cataloguing standards proposed by the Central Institute for Catalogue and Documentation: the adoption and application of the criteria introduced aim to achieve the main objective of sharing and disseminating information among the actors involved in the Cultural Heritage and Tourism sector [Bocconcino 2015]. In the work process briefly described, the adoption of and compliance with the standards are a guarantee for the creation of a quality database and therefore a "heritage catalogue" at the service of the administration and the community [Mancinelli 2018].

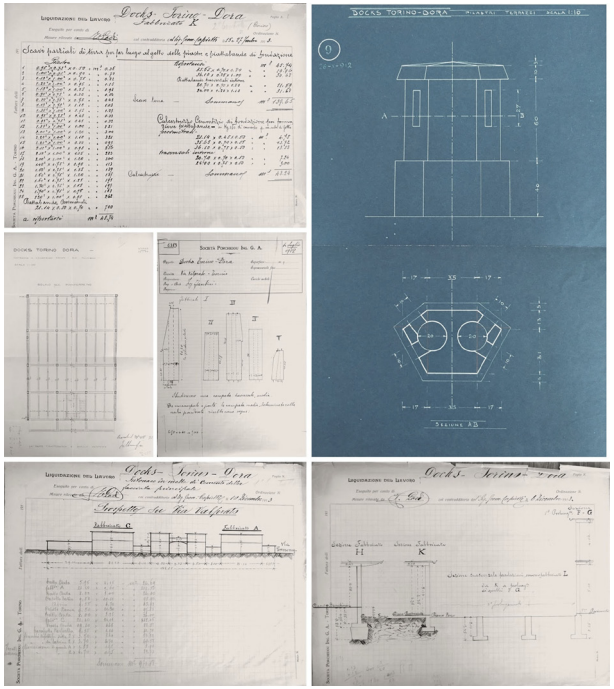
Following the documentary analysis, a survey campaign –direct and indirect– was launched on the buildings to obtain a digital representation of the architectural assets that make up the complex. The tool used for the collection of the different types of files and the photographic images and annotations was the same. Up to this point, the project has dealt with the conservation and dissemination of the Archive essentially in its three dimensions, geographical coordinates and time.

Having solved the issues related to the georeferenced sharing of the Porcheddu Archive, the supplementary sources and the field surveys within a single processing environment (see the previous paragraph and fig. 5), the addition of a further new dimension to the cognitive project introduced new challenges; once the sampling was obtained, further questions arose related to the very nature of the digital information models (fig. 8):

- how to encode the data obtained from the survey phases to be able to use them easily in the different 4D applications and for different dissemination and study purposes;
- how to make accessible the data and information deduced during the survey phases;
- how to relate the survey data to the data obtained from the archive documentation, and how to relate them by representing the collected data and metadata;
- how to archive data and metadata to make them available to the largest possible number of users;

Fig. 6. Photographic survey of the Docks Dora, March 2021 (source: photographs by the Authors).

Fig. 7. Some documents relating to the Torino Dora docks project (source: Archivio Porcheddu, dossier Torino 1910, volumes 37 and 38).



- how to represent and visualise the information and data collected in a single, user-friendly environment.

The approaches to the two models can only be qualitatively assimilated for three-dimensional visualisation of the asset, within a shared platform where related documents can be viewed. In these early stages, it was decided to develop those two models independently to understand the costs and benefits of the two approaches.
The digital model of the asset thus assumes the dual function of a means of communication and dissemination of data and metadata, and at the same time, it is also a virtual prototype that can be used to conduct further simulations and analyses [Donato, Bocconcino, Giannetti 2017], without sampling or testing the asset. In the first case, the use of the model obtained from the photogrammetric survey is more effective, in the second case the model elaborated in the BIM environment is more efficient.

Information model processing and information sharing

Over the years, numerous solutions for complex model viewers have been developed and presented, capable of processing interactive visualisations on web platforms. The following are some environments for the visualisation and sharing of 3D models resulting from the digitisation of Architectural and Cultural Heritage and related historical sources and documents.
These environments were considered in terms of functions, formats and operating platforms and led to the choice of the *Sketchfab* viewer for the application to the DISEG archive (fig. 9). As anticipated, the detailed study of the buildings that make up the Docks Dora complex was conducted by first elaborating a model in a BIM environment, obtained through the integration of archive sources (fig. 10).
This choice is supported, from a theoretical point of view, by the fact that the model can be considered as the place where the different temporal photographs (documents and surveys) of the analysed architectural asset are represented.The aim of the proposed research will therefore be to define and standardise a possible methodology for the survey and representation of digital models of architectural heritage, using BIM as a modelling process, implemented in its geometric forms through information

and data deduced from point clouds, to be able to add data and information to the models thus created that can be, in the first instance, shared through web viewers, and implemented and modified, using parametric and semantic objects [Lo Turco, Giovannini, Tomalini 2021; Brusaporci, Tata, Maiezza 2021].
From what has been considered emerges the need to understand the limits and potential of the models created:
Phase 01 HBIM model – the creation of the model of the architectural asset through the consultation of archive sources: the creation of the model with shared parameters and thematizations. The model sharing paths can be (fig. 11):
- sharing of data and metadata with other users by sharing the model in its native environment: opening of the model directly within the creation software;
- sharing the model by sharing and viewing in:
  - cloud viewers: simple visualisation of the asset's geometries and visualisation of the theming created in a BIM environment;
  - export of the model in CAD formats and import into 3D web viewers, where it is possible to manually associate notes and sources to the different geometries or parts of the model.

Phase 02 Point cloud model: generation of the point cloud of the asset with digital survey technologies, the possibility of querying, modifying and displaying the point cloud in different environments, with heterogeneous objectives and users. The model sharing paths can be:
- sharing of the cloud with other users by sharing the model obtained from the images in its native environment: opening of the model directly within the creation software, the possibility of interrogating the model, reading its geometries and elementary characteristics;
- model sharing and visualisation in:
  - BIM environment: import of the point cloud into the BIM working environment and implementation of the initial model with information and data deduced directly from the point cloud;
  - point cloud viewer: visualisation of the geometries of the asset, with the possibility of querying geometric data;
  - BIM model cloud viewer: visualization of the geometries of the asset and visualization of the thematizations created in the BIM environment;

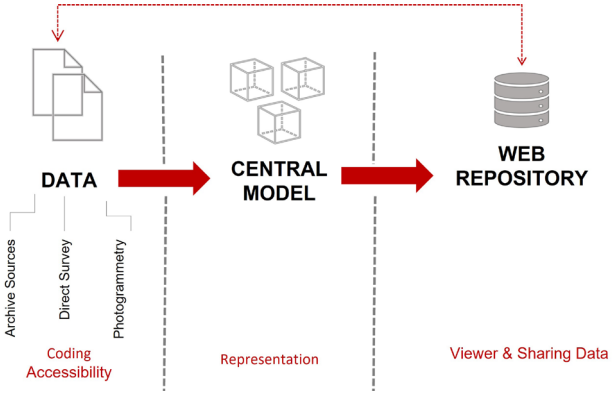


Fig. 8. Data workflow - representation - sharing.

  - 3D web viewer: possibility of associating notes and sources to the geometries of the model;
- exporting the model in CAD formats and importing it into 3D web viewers, where it is possible to manually associate notes and sources to the different geometries of the model. The model can be made public by sharing it on a web platform, where users can interrogate the model and view the associated sources and data.

Conclusions and application developments for a return

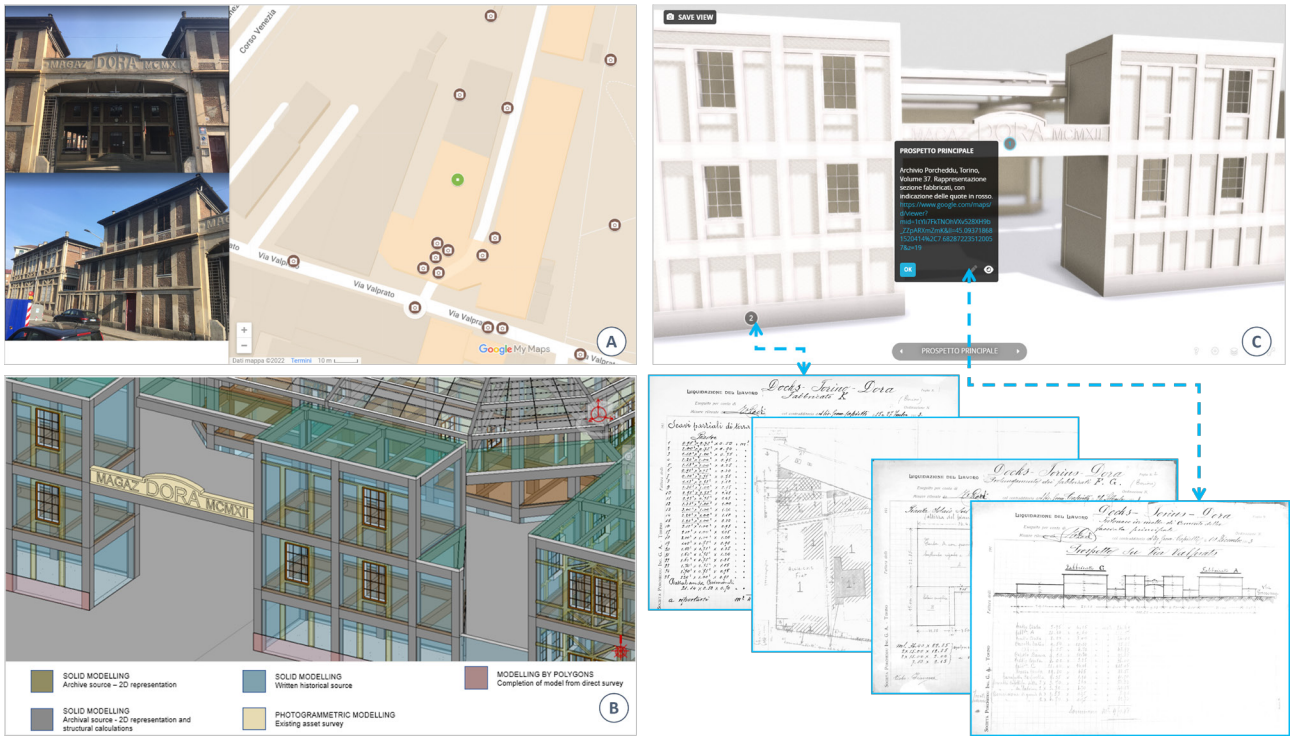
It is evident how the contribution of the disciplines of representation within the project of ordering the knowledge for an urban centre involves aspects that range from the knowledge of surveying to the setting up of multi-relational banks for the treatment of data, to the interaction with GIS, DBMS, BIM and WEB systems. On the one hand, it is necessary to faithfully render, without loss of informative quality, maps capable of representing, in synthesis, demanding conceptual elaborations of a logical deductive type; at the same time, it is necessary to make uninterpreted data instantly available, as well as tools for analysing the same, capable of allowing the various players in the field to carry out analyses that could not have been foreseen in the research project as conceived in its initial stage. Finally, it is necessary to provide multiple queries for extensive thematic filters.

Fig. 9. A brief overview of the functionalities of the main off-line and on-line 3D viewers and navigators.

Fig. 10. Source sharing environments: A. Google My Maps view; B. BIM model with theming of sources; C. Sketchfab model with annotations and links to archive documentation.

3d Viewer	Works on			Source		Data Import																	To do						Share	
	web	windows	ios	open	closed	.PLY	.obj	.blend	.fbx	.glb	.3dc	.asc	.3ds	.abc	.dea	.zae	.igs	.ges	.las	.stl	.dwf	.dxf	HiRes	.x3d	3d visualizer	Interactive Tours	note	Settings materials	Lights	Environment	Slice	Measure	yes	no
Nexus		■				■	■																		■	■							■	
3dHop*	■		■	■		■	■																		■	■	■	■	■			■	■	
Sketchfab	■			■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			■	■	■					■	■	
OpenSource3d		■		■			■	■	■				■		■					■		■		■	■		■					■	■	
Smithsonian Museum X3D	■				■																					■	■	■	■	■	■	■	■	

* Meshlab import: .ptx | .pts | .xyz | .txt (generic ASCII list of points)



The above considerations, some of which are methodological, others operational and descriptive ones, highlight an issue that is considered fundamental and which returns to the fore when it is necessary to transfer knowledge of technical assets through the various forms of widespread communication accessible to heterogeneous audiences. The selection of effective, punctual and rigorous elements, without the risk of leaving out elements of interest or foundations, can inevitably lead away from the original languages of elaboration. For this reason, the digital reproduction of the materials, capillary and curated, could represent an independent way of sharing, but in constant dialogue with the critical synthesis that in parallel is implemented and recorded within the information system.
Texts, formulas, diagrams, tables and drawings are in a complementary relationship with each other; in different forms, they often represent the same content and are mutually enriched through the direct and material reading of the documents with clues that cannot be fully restored through digital acquisition, such as the consistency of the paper and the inks, which can also be revealing of the methods and times of execution of the works.
From what has been developed, it can be deduced that to obtain a model that represents the architectural asset in all its parts, as exhaustively as possible, and for it to be shared by as many users as possible, it is necessary to create a clear workflow that defines all the steps of acquisition, modelling and sharing of the data and information that define and characterise the asset (fig.12).
To set up a parametric model of an existing asset, it will therefore be necessary to determine and characterise the flow of data and information that flows from the various sources –archival and survey– into the model, becoming an integral part of it, implementing the geometric characteristics that define the asset with data and metadata, which are also of fundamental importance for understanding the asset. The same parametric definition of the asset, and all its components, will have to maintain a correct semantics: each digital component of the asset will have to have the same characteristics as its real correspondent and a correct taxonomy, to avoid ambiguities. In this regard and with a view to collaboration for future development, we mention the interesting

Fig. 11. Model distribution scheme and its visualisation.

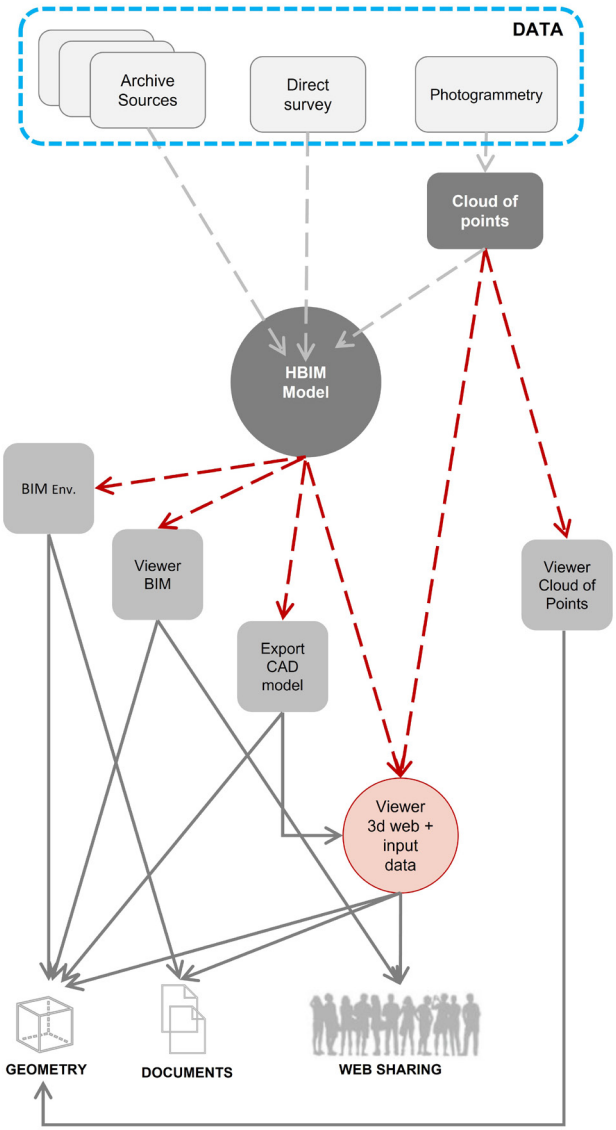
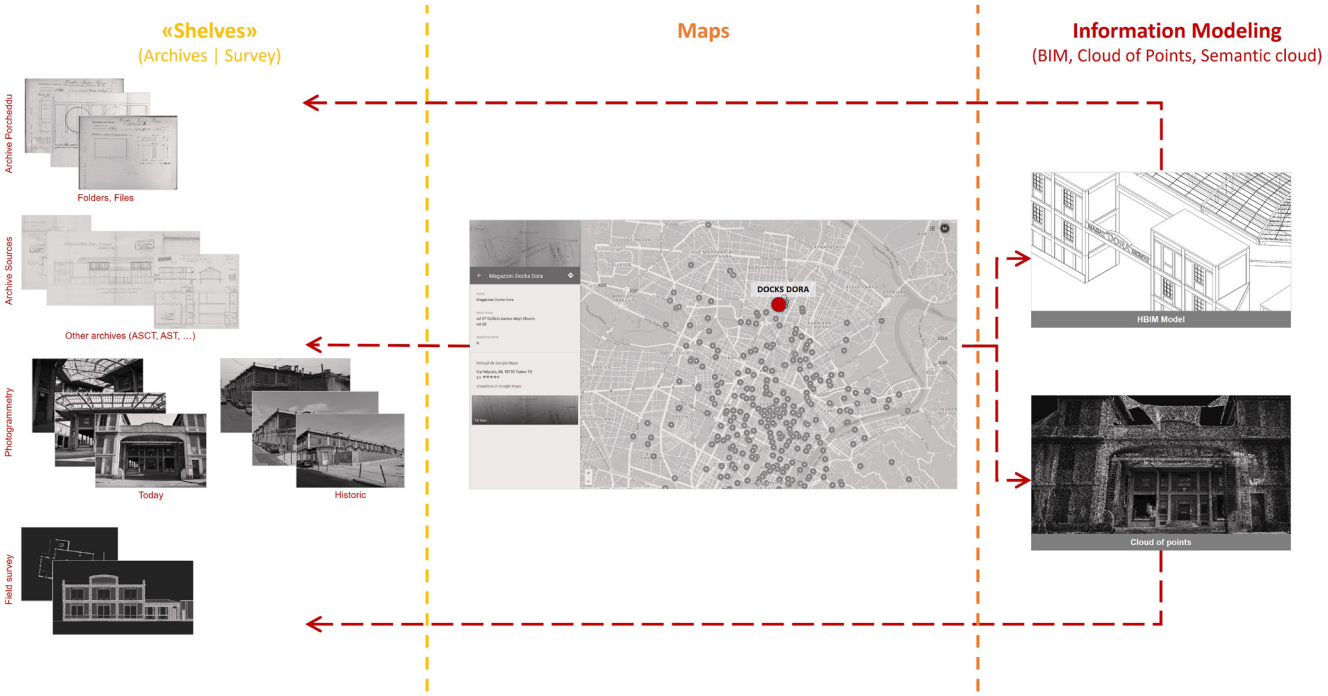


Fig. 12. From the map to the information model, from the information model to the shelves.



project that is being carried out within the Politecnico di Torino "Architectural Cultural Heritage point clouds for classification and semantic segmentation" [Matrone et al. 2020] [4].
As illustrated, the project for the enhancement of the heritage preserved in the Archives takes into account these aspects of care and sensitivity, going beyond certain experiences and integrating with policies that at the University level incorporate the dynamics of the individual Departments. The dissemination project, which is constantly being refined, must respect the principle of conservation and must increase the methods of direct access to the documents. The experimentation, which started years ago on the occasion of the study day held at the Politecnico di Torino in November 2004 [Novello, Bocconcino 2006], today is no longer just an ideal path.

Credits

We would like to thank Professor Pina Novello who, at the end of the 1990s, initiated and coordinated the work of studying and sharing the DISEG heritage. The sections *The cultural context and research activities*, *Fields of experimentation: Archivio Porcheddu at the Politecnico di Torino*, *Graphic experimentation in reinforced concrete design*, *A challenge: to disseminate and communicate through light and widespread systems, from the shelf to the map*, and *Conclusions and application developments for a return* were mainly edited by Maurizio Marco Bocconcino; the sections *Docks Dora in Turin: from map to model*, and *Information model processing and information sharing* were mainly edited by Mariapaola Vozzola.

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Notes

[1] The construction company Porcheddu Eng. G. A. (Giovanni Antonio Porcheddu, engineer and founder of the company, Agent and General Concessionaire for Upper Italy of the patent of the French builder François Hennebique) was set up as a company in 1896 and operated in Italy and some Italian colonies until 1933. The business had already been started in 1894 by the young engineer, who had graduated from the Royal School of Application for Engineers in Turin in 1890. The founder's lively entrepreneurial skills and the quality of his training were decisive factors in the success of the initiative: As a pupil of Camillo Guidi, professor of Graphical Statics at the School from 1881-82 and of Construction Science from 1887 to 1928, it is likely that the young Porcheddu absorbed the strong theoretical and applicative tension and the innovative spirit that led him to take an early interest in the construction of béton armé, as well as the experimental results from the tests on the new system that Guidi conducted in the laboratory attached to the Cabinet of Constructions [Novello, Bocconcino, Donato 2017].

[2] The documentary and iconographic sources in the Archivio Porcheddu are a precious heritage that is indispensable for investigating and understanding the birth and spread of reinforced concrete technology in design and construction practice. The archive was handed over to the Laboratory of Wood, Iron and Reinforced Concrete Constructions directed by Professor Giuseppe Albenga, who was assisted at the time by a young Augusto Cavallari Murat, after the company was liquidated. It was Professor Cavallari Murat himself who, starting from this archive, had studied several low arch cellular bridges such as the Risorgimento bridge in Rome built by the Porcheddu company in 1911. The order in which Professor Riccardo Nelva and architect Bruno Signorelli carefully arranged the files reflects the original cataloguing of the files made by the company: 385 files with approximately 2600 works [Nelva 1990].

[3] <https://www.biblio.polito.it/eventi_culturali/2020/bibliopolidate_politodate/l_arte_di_fabbricare> (accessed 1 March 2022).

[4] <http://archdataset.polito.it/> (accessed 1 March 2022)

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