Establishment of a Complex Database for the Study of Cultural Heritage Through the Reading and Analysis of the Traditional Architecture of Upper Kama

Sandro Parrinello and Federico Cioli

Abstract The Upper Kama Region, located north of the city of Perm in the Volga Federal District of Russia, represents a frontier territory between the East and the West and an important crossroad for trade. The numerous religious complexes and industrial settlements scattered throughout the entire territory, buildings of considerable architectural interest, are often left in poor conditions and in a state of neglect. The aim of the research is to implement integrated digital survey methodologies in order to create tools for the management and enhancement of the cultural heritage of the Upper Kama Region. The research, which takes place in the three district of Usolye, Solikamsk and Cherdyn', was carried out thanks to the collaboration between the DAda Lab of the University of Pavia and the Perm National Research Polytechnic University - Scientific Board headed by Prof. Sandro Parrinello and Prof. Svetlana V. Maximova - and is still ongoing.

Keywords Heritage Informatics · Culture Big Data · Cultural Heritage Risk · 3D Survey · Stroganov Architecture

1 Introduction (SP)

The documentation of a cultural heritage, as dispersed as that of Upper Kama traditional architecture, requires the elaboration of a new way of understanding the meaning of the target sites. Upper Kama Region has always attracted the interest of historians and researchers, representing a border territory between East and West and a meeting point between European and Asian culture. The region preserves several

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Fig. 1 Panoramic view of the surrounding landscape around Cherdyn and the Kolva River, a tributary of the Višera River

examples of a peculiar architecture, (rich) in orthodox complexes and neoclassical industrial settlements of the eighteen century. The Upper Kama heritage is currently experiencing a period of decay and abandonment, concentrated on the rural landscape, the last stronghold of the tradition of provincial Russian architecture. The aim of the research is to integrate different digital documentation methodologies, in order to create an instrument of analysis and evaluation of the condition of the cultural heritage for the development of territorial renewal plans [11]. The importance of Upper Kama documentation is due particularly to the lack of a detailed census archive from survey analyses that provides precise information on the quantity and quality of monuments and environment. During the 20th century, numerous historians and researchers have attempted to document the wide phenomenon of these religious buildings combined with industrial archeology complexes.[1] Nevertheless, these researches do not provide a global heritage census and the technical basis for preservation processes, which are necessary to maintain and promote the cultural tradition of the region (Fig. 1).

2 Territory, History and Architecture of Upper Kama (SP)

The Upper Kama Region is an emblematic site where monumental architectures and widespread criticalities coexist: heterogeneity of architectural features, stylistic and constructive variety, multiplicity of construction materials and related pathologies of degradation and conservation. This characterizes Upper Kama basin as a dispersed

[1] A. S. Teryohin, G. D. Kantorovich, I. V. Makovetskiy and V. A. Tsypushtanov provided the most important contribution to this research, presenting their work regarding culture and architecture of Upper Kama settlements in 'Monuments of stone architecture of XVI–XVIII in Solikamsk (1970). In 1988, Kostochkin [5] wrote a monograph entitled "Cherdyn, Solikamsk, Usolye", a work that integrates all the previous research activities on the Region. The Perm Scientific Restoration Atelier carried out several activities of inventory, documentation, survey, and developing conservation and restoration projects for the Upper Kama region and in 1986 provide reliable data regarding the majority of existing monuments. Recently, a study about the Upper Kama architecture was conducted by W. Brumfield in form of photographic surveys "Solikamsk: Architectural Heritage in Photographs" (2007), "Cherdyn: Architectural Heritage in Photographs" (2007), "Usolye: Architectural Heritage in Photographs" (2012). Today, the Perm Krai Center for Monuments Protection is in charge of the Upper Kama heritage preservation, establishing projects for the definition of "Protection zones", as the one regarding the Old Town of Usolye.

system of potential cultural value added to the territorial context, explicable through a targeted system of knowledge, intervention and promotion. The territory extends in the north of Perm Krai, west of Ural Mountains, bounded by Komi region in the North. Mineral resources and the role of commercial crossroads of imperial period has led the territory to an intense cultural and architectural development focused between the 15th century, with first industrial settlements, and the 18th century, till the rapid decline of Russian October Revolution (1917).

The founding of saltpans by merchant families, such as Stroganovs or Golitsyns, led to the development of urban settlements with residential buildings and orthodox complexes, churches, bell towers and family chapels. Salt trading business, that through Urals reached Siberia and, then, China, led to the spread of numerous urban centers, associated to current districts; Solikamsk (1430), Cherdyn (1535) and Usolye (1606).[2] The comparative study of sites highlights stylistic coherence and unitary shapes and themes, related to each other. Masonry buildings, characterized by a mixed style between Muscovite baroque and European influences, gradually replaced the typical wooden architecture of industrial settlements. Monumental sites and isolated religious architectures enriched the landscape along the river basin, characterized by stylistic uniformity in decorative brick elements, such as frames with "*zuchkov*" motif and majolica theme of "sirens". Many churches have a main space covered by onion domes with a large entrance refectory, while bell towers have an octagonal plan section, surmounted by thin pinnacles, with semi-circular "*zakomary*" covered in colored ceramic tiles. Residential buildings are divided into two main types: winter residences, characterized by wooden roofs with trusses, separated entrance compartments and decorated stoves; and summer residences, with similar constructive technologies but stylistically simpler and more contained (Figs. 2 and 3).

Architectural heritage of Upper Kama derives by a localized cultural development contained in a limited historical duration, with European influences in constructive and stylistic characteristics, spread through cultural exchanges along commercial routes. The region consisted in numerous sites interconnected by a unified historical, architectural and stylistic language that distinguishes the territory as a unique cultural basin, requiring equally unified practices of study, expression and communication [9].

The abandon of Upper Kama region, due to the collapse of middle-class society, at the beginning of the 20th century, lefts its architectural heritage to decay. The opening of railway lines decentralized the districts with respect to new commercial routes, and

[2]Brumfield [2]. In his contribution the author provides an overview of the historical and territorial evolution in the districts of Cherdyn and Solikamsk. "*Among the earliest Russian settlement in the area was Solikamsk, apparently founded around 1430 by the Kalinnikovs, a wealthy merchant family from the northern town of Vologda who were intent on developing the ample salt springs in the vicinity of the middle Kama River*" (pg. 318). "*In the 1450s and 1460s a new wave of Orthodox missionary activity accompanied this move, which resulted in the construction of the first churches in the middle Urals and the establishment in Cherdyn' of the area's first monastery, dedicated to Saint John the Divine […]. After a fire destroyed Pokcha's log fort in 1535, Cherdyn' was officially designated a town and became the administrative center of the large Perm territory*" (pp. 319–320).

Fig. 2 Upper Kama basin and its contest; Upper Kama districts; monumental sites and examples of architectural complexes. Picture from H2020-MSCA-RISE-2018: PROMETHEUS

Fig. 3 Decorative and constructive apparatus, materials and technical solutions applied in Upper Kama architectural heritage

development plans of Kama River involved widespread flooding of many settlements and sites, reducing to one third of the original the existing heritage. The need of a unified digital documentation, in support of administrative management and conservation practices, reflects the definition of complex databases reach in information models libraries on constructive elements typical of Upper Kama architecture.

3 The Case Study of Usolye (SP)

The research aimed at the creation of a digital database that describes the features of Upper Kama architectural and environmental heritage. For the acquisition of precise information about the current image of the place are developed innovative methods to survey and geo-reference data. The integrated methodology of research, combining

traditional and modern methods, perceptive investigations and precise digital measurements, want to assess the state and condition of historic complexes and sites. The documentation of Usolye as case study, conducted during three years of research, is the starting point of a more ambitious project aimed at the analysis and representation of the architectural and environmental features of the entire Upper Kama region. The variety of monuments and the complexity of the environmental system led to the choice of Usolye as a pilot project [3]. The city, founded by the Stroganov Family in 1606 as an important industrial settlement on the Kama River, was a commercial outpost for the production of salt in Urals (Brumfield [1]. The historical center contains a couple dozen buildings, some residential and others related to the former industrial and commercial function of the complex. The Stroganov Ensemble, consisting of the Chamber, the bell tower, and the Transfiguration Cathedral, has been the main subject of the research. The three buildings, built in the XVIII century by the family, represent a rare and one of the most important examples of Stroganov art, mixed with local workers. Their image has changed over the centuries, modifying the prospect along the river, due to numerous fires and floods that have periodically affected the territory. Furthermore, the analysis moved from the architectural complex to the environmental system, in order to understand the interaction between the landscape and the urban settlement. The key element that characterizes the landscape of Usolye is the river and its relationship with the banks. The site consists into four smaller islands, connected to one another by bridges or highways. The vegetation of the islands is characterized by the diversity of wild marshes, meadows, medium height hygrophilous trees, such as birches, willows and wild cherries, dominated by tall black poplars, which stand as solitary rulers. The elements, both architectural and natural, interact with each other creating a unique system.

The organization of two summer schools, set in the Historic Centre, reach with remarkable examples of religious, residential and industrial architecture, aims to the experimentation of different methodologies of analysis in order to develop renewal proposals also valid for similar isolated complexes in the north of Upper Kama. The notoriety of Usolye guaranteed visibility to the project, feeding the debate between citizens and administrative bodies about the preservation of local cultural heritage. The survey conducted with 3D laser scanning and photogrammetric methodology (Structure from Motion) aimed at the development of three-dimensional database, which makes possible to integrate and improve information from other investigation, such as structural inspections and thermographic surveys. A detailed census of the existing buildings, through the filling out of a specific data sheet, supports the three-dimensional data in order to provide precise information about the state of preservation and the architectural features of each building.

4 Methodologies for Investigation (FC)

Through the digital representation, the project is going to re-establish the cultural value of the place, helping the development of a concept for the preservation of the

authentic image of the architectural environment, planning processes for its transformation and valorization. Accurate surveying operations constitute the fundamental basis for the critical analyses of architectural elements, settlements or territories. Furthermore, they are necessary to plan and manage conservation, restoration and valorization activities. The more advanced models of laser scanners, together with photogrammetry and Structure from Motion (SfM) methodologies [7], create a global overview of the surveyed object, useful to plan the post-production processes. They concern the creation of digital drawings and 3D models, representing plans, sections and facades, integrated by detailed texture in order to return an accurate and realistic image of the current condition.

The three campaigns of laser-scanner survey, conducted with the use of a Leica ScanStation C10, concerned the Stroganov Chambers (2014), the Stroganov Ensemble, with particular attention to the Steeple and the Transfiguration Church (2015) and the residential complex along the river (2016). The acquisition of data were implemented by a photographic campaigns close range, aim at the built of 3D models (SfM) through which extrapolate metrical reliable textures, containing useful information about the morphology and preservation of constructive elements. These models, which refer to the coordinate system of the laser scanner survey, enriched the archive, constituting a significant part of the complex database together with the information provided by the data sheet census [8].

The interpretation of historical maps allows the detection of the traces of the past, such as ruins and foundations, reconstructing the memory of the place. Cartography and drawings, owned by the municipality archive and the Stroganov Centre, were the starting point for the Old Town analysis. They provide a useful documentation for the creation of thematic maps, in order to identify the main types, functional features and remaining signs of the disappeared architectures. The census activities concern the cataloguing of constructive systems and technological details through a data sheet divided in three main sections: the first, ‘general information’, provides a framework of the building related with its surrounding; the second, ‘visual description’, highlights stylistic features, such as dominant colors, visibility and interaction with the urban fabric. The last section, ‘architectural-constructional analysis’ shows preliminary surveys, 3D models and pictures, representing plans, prospect and sketches, focusing on the constructive system, materials and typology [6].

The data collected during the investigation process served to create detailed two-dimensional documents that faithfully represent plants, elevations and sections of the Stroganov complex and 3D models of the decorative elements, which became integrated instruments of the digital database. All the data contribute to establish the digital archives, structured as a cascade system, which connects the territory with the single architectures and its constructive elements. The georeferenced database is a unique archive, which allow a smart usability and interpretation of data, enabling to deepen the knowledge about the complex. This led to the creation of an atlas of architectural elements that allows a comparison between the various settlements, which is necessary in order to develop an integrated renewal plan on a territorial scale (Figs. 4 and 5).

Fig. 4 3D point cloud of the Stroganov Complex of Usolye, derived from the laser-scanner survey. The figure shows the Transfiguration Church, the Bell tower and the Stroganov Chamber in the background

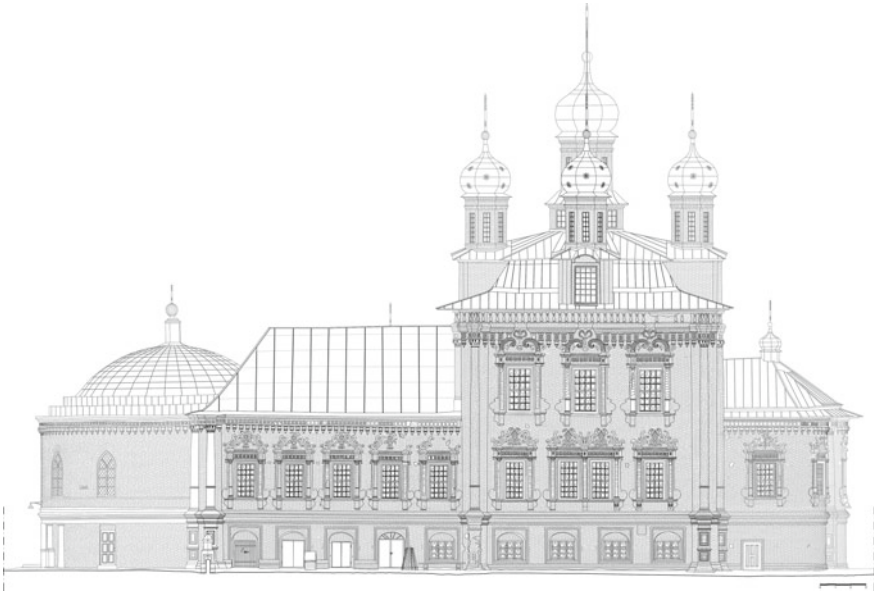

Fig. 5 CAD Wireframe drawing of the Transfiguration Church in Usolye

5 The Development of a Complex Database (FC)

The documentation of the disperse heritage of Upper Kama, connected by a unique databases obtained by the digital survey, as advanced instruments for the managing of the restoration measures on a regional scale, is the aim of the project PROMETHEUS, proposed for the Horizon 2020.[3] The databases consists in informatics containers, as digital archives reach on cultural and scientific information, constantly updatable and strictly connected with the physical reality. Databases are potentially a new generation of instruments, able to establish an interaction between interdisciplinary fields.

The identification of categories of typological and identifying constructive features of Upper Kama Region has been necessary in order to develop the structure of digital archives, managed as "libraries". Through them, it is possible to define and manage information models, unified and classified in architectural building families, with a geometric "shell" implemented through the informative content of historical, material, constructive, technological and estimative data. Each unit will constitute a typological module applicable for the definition of architectural models, both directly and duplicated with partial variations of conformity to the specific context, developing a "modeling mitosis" process and expanding the digital archive. "Digital Modeling" thus finding a concrete application as "Procedural Modeling", developing a grammar of shapes based on the identification of variants and invariants that define archetypes of the architectural elements, which can be summarized in descriptors belonging to different information fields. The definition of a library of Upper Kama heritage thus becoming a necessary phase and a fundamental input, in virtue of constructive and material richness found in its architectural sites, in order to define a database management system (*H2020-MSCA-RISE-2018: PROMETHEUS*) (Figs. 6 and 7).

Actually, there is a gap between three-dimensional databases and design instruments (e.g., 3D models and 2D drawings), that the application of BIM processes is trying to bridge [10]. The project, working from territorial to detailed scale, allows to estimate the efficiency of the parametric models and offers the possibility to optimize the database, integrating data with parametric digital drawings, representing the quality of the place. The myth of a global database for the preservation of cultural heritage is a matter of international concern (as confirmed by several European

[3]The project PROMETHEUS, proposed for the Horizon 2020, Marie Skłodowska-Curie Research and Innovation Staff Exchange (MSCA-RISE-2018), started from the collaboration between the universities of Pavia, Valencia, Florence, Granada, Perm and the two small businesses SIΣMA S.r.l.s. and EBIME S.L. In particular: the Department of Civil Engineering and Architecture – DAda Laboratory of UNIPV—University of Pavia (Team: Prof. Sandro Parinello, Dr. Francesca Picchio, Ph.D.s Raffaella De Marco, PhDs Federico Cioli); the Department of Architectural Constructions—I + D+i Laboratory of UPV—Polytechnic University of Valencia; the Architecture and Urban Studies Department—DSLab of PNRPU—Perm National Research Polytechnic University. The aim of the project is the documentation of the complexity of Upper Kama architecture and the development of strategies for the analysis and management of data applicable to European Cultural Heritage Routes.

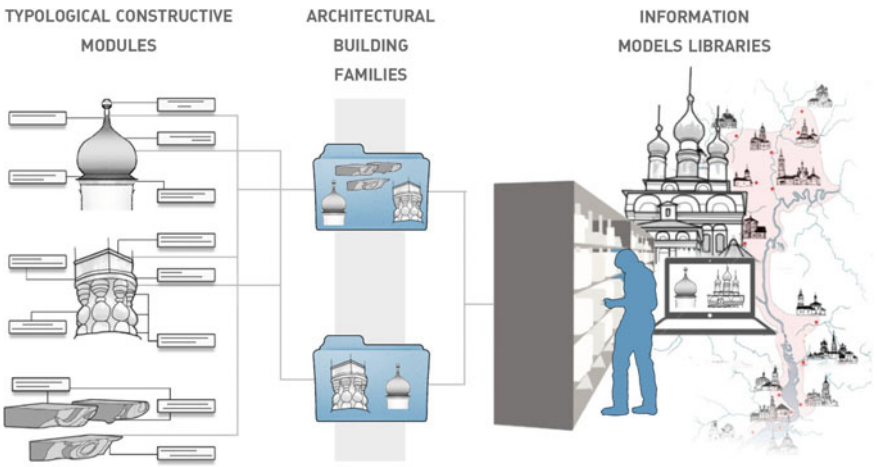

Fig. 6 The schema shows the structure of the work in order to organize the digital database. The aim of the project is to develop Typological Constructive Models and to define Architectural Building Families with a high level of details and accuracy in geometry. Picture from H2020-MSCA-RISE-2018: PROMETHEUS. Graphics by R. De Marco

Fig. 7 Some examples of religious architecture dispersed in the Upper Kama Region and 3D model of the Taman church obtained with SfM detection

projects). The main problem of this type of archives is the usability, which often do not permit to appreciate the cultural background of the place concerned. The flank of databases with an appropriate representation is a challenge, necessary to improve the functionality of digital systems. The relationship between information content and drawings seems to be the only way to develop strategies for the promotion of virtual systems aimed at the documentation.

6 Conclusions (FC)

The analysis highlights several issues, regarding architectonic and structural conditions of the buildings, which are in danger to disappear and require restoration and consolidation works. The documentation produced is the base to start a preservation and renovation project and allows to analyze the issues involving the site, from the landscape to the single architectural elements, understanding materials and degradations. These conditions, reflected all around the Upper Kama Region, led to the development of thematic maps, connected with the digital database, in order to highlight the main issues that cross the territory all along the Kama River. The methodology, developed during the application at the case study of Usolye, is replicable to the other architectural complexes. Furthermore, could be experimented to other cases of dispersed heritage, which concerns a system of relationships, features and cultural values disseminated at the territorial level. It makes the vast amount of information, deriving from such heritage complexes, accessible and usable in order to manage and develop informatics system and touristic thematic routes. The importance of preservation and documentation involves both tangible and intangible features:

> As a monument and a centre of high culture, the Lavra is infinitely necessary for Russia, and in its entirety, what's more, with its day-ta-day existence, its very special life that has long since disappeared into the realm of the distant past. The whole distinctive organisation of this vanished life, this island of the fourteenth-seventeenth centuries, should be protected by the state with at the very least no less care than the last bison were protected in the Belovezh Forest [4].
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> Florenskij P. Il rito ortodosso come sintesi delle arti, pg. 110

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