An "Italian-Chinese" Combined Methodology for the Philological Investigation of an Ancient Building in Accordance with the Real Physical Condition, Structural Problems and Pathology of the Materials

Paolo Vincenzo Genovese(✉)

School of Architecture, Tianjin University, Tianjin, China

Abstract. Due to the complexity of the physical condition of ancient architecture, the author proposes a comprehensive method for its investigation, which combines the practices carried out in China and Italy in the field of data acquisition, in the perspective of a philological restoration. The Chinese practice is accurate and logical in the categorization and positioning of the construction elements. The restoration in Italy is very descriptive and evocative to clearly define all the pathologies of the architecture and the visualization of its problems.

The conformation of the building is acquired using 3D scanning tools to generate plans, facades, and sections which are all verified on-site. All nodes, key points, constructive elements and materials are categorized, numbered, defined and measured in their quantities. A description of all the structural problems or pathologies of the surfaces and materials is documented, defined and analyzed following a strict categorization process. Finally, they are visualized through the use of categories, patterns and diagrams. The author presents a combined method of investigation of the building Yúqìngtang 馀庆堂, in Zhájì 查济村 village, Ānhuī 安徽 province. This paper will describe some difficulties and solutions which emerged during the elaboration of this methodology, including some problems that remain unsolved.

Keywords: Historical building preservation · Philology · Material preservation · Combined "Italian-Chinese" restoration method

1 Background: Case Study, Research Area and Main Topic. Initial Questions

The idea for this paper came from some specific practical and theoretical questions, which emerged during a workshop organized by the School of Architecture of Tianjin University in Zhájì 查济村village, Ānhuī 安徽province, P.R. of China in April 2017 under the supervision of the author. The work on-site was divided into several teams. The specific task of the group led by the author was the philological investigation of an ancient building in this area: Yúqìngtang 馀庆堂, an ancient family hall dating back

S. Xu et al. (Eds.): *East Asian Architecture in Globalization*, pp. 166–186, 2021.
https://doi.org/10.1007/978-3-030-75937-7_14

to the Qing Dynasty. The reason this building was chosen is because of the high quality of its architecture and the relative simplicity of the case in terms of damage and problems, which permitted a group of students to practice the philological approach on problems and pathologies of the building. The Yúqìngtang is in a relatively good condition of preservation but presents some damage, which can be typically associated with an ancient building, such as mold, fungus, partial structural damage, roof degradation, etc. These problems are not particularly pronounced, thus allowing us to approach them and primarily focus on the method of investigation.

Our initial intention—at least at the beginning of the survey—was to offer the students a method for data acquisition and survey of an ancient building in China based on a philological approach related to our experience and expertise in Italy. The basis of our method was a complete and precise understanding of the physical state of the building, with the intention to categorize every single aspect of the material state, using a scientific method of categorization and expression of all the problems, in terms of materials, surfaces, and structural elements. The reason for this process is based on a typical Italian (also common in Europe) vision of the ancient tangible heritage. In this perspective the ancient heritage is unique and irreplaceable and any partial or total substitution of its part is unacceptable. This is the reason why the intervention on the ancient buildings is primarily directed at preserving the original material, conformation and state of the physical part of the artifact.[1]

At the same time, during the investigation, we noticed how important and how accurate the Chinese methodology of categorization and classification of the local architecture is.[2] If the “Italian method” was excellent in terms of preservation of the original identity of the architecture, and able to keep the original status of the building with its process of analysis and intervention, then we could avoid instances where it was often unable to categorize and accurately describe the Chinese building. The logic, the form, the structure, the material, the typology, etc., are too different from the Italian and European cases. For this reason, a combination between the two methods was necessary. In fact, the two methods were both incomplete.

The initial intention was widely accomplished but during the workshop some radical and interesting problems surfaced. This paper intends to illustrate these problems, and questions the partial solutions we provided in the creation of a comprehensive method for a precise investigation in the philological study and preservation of the ancient building.

2 Initial Data Acquisition and Management: Some Unsolved Matters During the First Phase

The preliminary phase is based on a method that has already been applied several times in our practice of investigation on ancient buildings. It involves recording the existing

[1] The topic of architectural restoration in Italy is extremely complex, and due to the constraints of this paper it cannot be properly illustrated, but the bibliography (mostly in Italian) is very abundant. For more information, it is recommended to consult the works of Carbonara (1997), Casiello (1996, 2008) and Conti (2002).

[2] The most representative works concerning the history of restoration in this country are those of Chen 陈铭达(1955), Liang 梁思成(1963) and Luo 罗哲文(1959).

building using the 3D laser scanning device Faro 330[3] with the help of a team of experts supervised by Prof. Bai白成军[4] from the School of Civil Engineering in Tianjin University, whom we cooperate with on several similar cases. This data acquisition process will not be analyzed in this paper because it is not ours. The result was a large file (approximately 50 GB) based on cloud-point data generated by the software packages *Scene*, *Cyclone* and *Geomagic*. Plans, facades and sections of the building were produced in the days that followed.

The next step for our team was to verify all the dimensions of the building using a laser meter. This part of the survey, though redundant, was necessary in our practice because the building under investigation was extremely old and still inhabited by the owner, with some sections of the building occupied by furniture and waste materials. Consequently, the 3D scanner was unable to reach every part of the rooms. These are represented as "shadow areas" on the final picture, white areas with no detail, which renders them as objects of possible, yet severe mistakes.

Because of the nature and quality of the final output resulting from the 3D scan, it was necessary to take a complete set of photographs of every facade (internal and external) and roof details.[5] The 3D-scanned facade was extremely accurate in terms of dimensions but without details; the photographs captured by camera were the opposite, accurately detailed but deformed. These photographs were used to complete the 3D-scanned facade to produce more detailed images of the pathology. The comparison between these two methods was exhaustive, at least for the purpose of our research. The two sets of materials (3D scans and pictures) were amalgamated in order to redraw the plans of the building, including all facades, sections, and roof plan.

The redrawing process was imperative, as the output became the basis for further investigation and categorization work. Our method intended to overlap the realistic redrawing of the building with diagrams and patterns created by the team, which indicated the nature of the pathology.

The investigation on-site was divided into three main tasks:

- **(A)** Accurate listing of all the details of the architecture under investigation (walls, pillars, doors, floors, etc.). This is based on a multiple grid system. In the case of Yúqìngtáng only a double grid system was necessary. Section 2 of this paper provides a deeper description of this process;
- **(B)** Illustration of the problems related to the building's structure and material collapses;
- **(C)** Accurate analysis and categorization of the degraded surfaces and materials using a method specially elaborated by our team.

[3] Average precision of 1 mm.

[4] The other members of the team are: Zhang Zhiqiang 张志强, Zhang Zhiyong 张志永, and Wang Shuo 王硕.

[5] We used various cameras, especially a large-format digital camera (Pentax 645D).

The process of investigation is not neatly divided into separate phases, because phases (B) and (C), for example, and the relative categorization process have to be linked together with certainty, and accurately and logically localized into a precise mapping (Fig. 1).

Fig. 1. Comparison between 3D image and photography.

One question that was raised during the initial phase of investigation concerned the creation of a global but flexible method or scientific approach aiming at creating a philological process of restoration of the ancient Chinese buildings. Initially we limited our interests to the application of the existing methods of categorization for pathologies and structural problems, etc., of the building under survey. Therefore, the team sketched out some diagrams that should precisely include all the listings under (B) and data sheets for (C).

We then compared the results between AutoCAD and Vectorworks. The latter was more effective, especially in the design of repetitive details (Fig. 2).[6]

[6] In our case, this software is more flexible and effective when a specific element (the shingle, in our case) is a repetitive element of the roof but with certain variations.

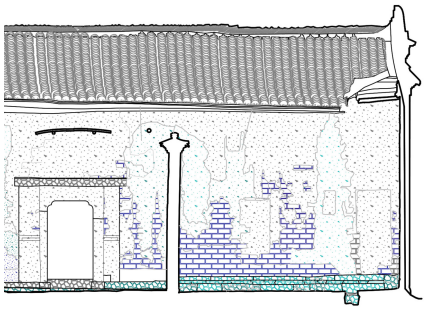


Fig. 2. Vectorworks' performance regarding repetitive details.

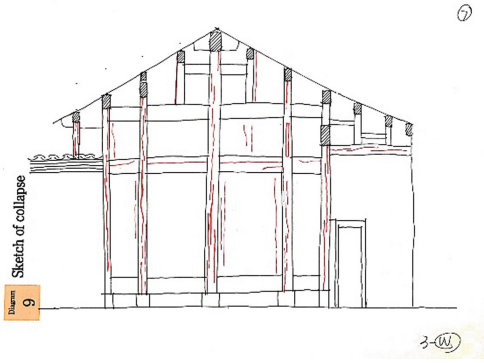


Fig. 3. Sketch of structural cracks.

These materials can illustrate the specific problems of the building. The structural problem was sketched out in tables illustrating the cracks in red (Fig. 3); the sketches were extensive enough to analyze, and detail the *reasons for the collapse.* In our point of view, the main goal in solving the structural problems, irrespective of size, is to restore the initial solidity of the building and not simply "cover up" the problem with an operation of "make-up", a practice so common nowadays. These sketches are quite simple to do, but surely illustrate a very sophisticated problem: from the beginning it is vital to understand the *reasons for the collapse* in order to include enough surface and details in the sketches to illustrate the complete area which could be the cause for the structural problem. Because these pathologies are usually neither isolated nor created by a single reason, it is mandatory to extend the area of investigation and the description of the building into drawings and to extend it also to the neighboring areas, because the reason of the structural problem could be caused by other factors.

The data sheets for (C) (Fig. 4) are also our original elaboration based on our personal experience on historical building investigation and restoration, such as in the case of Jìngyuán 静园in Tianjin. They are based on one sheet: the front page illustrates the specific problems, while the back page shows the possible solutions. The logic of these diagrams is simple: every material and pathology has a definite and separate sheet.

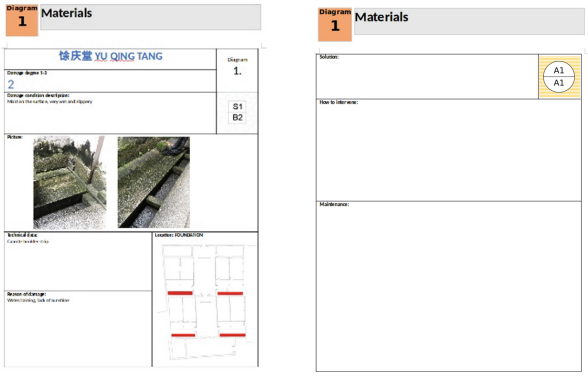


Fig. 4. Diagrams of the building’s pathologies and respective solutions.

For example, this means that if a portion of the plaster in a wall is affected by structural problems, the matter and its relative reasons are described in a specific diagram. But if the same material is affected by rainwater, this pathology is described in another sheet, with a completely different process of solution. This process will be repeated for every single problem of the building, with the final results of creation of a conspicuous number of diagrams that will finally be accurately categorized: every diagram (and consequentially every material and every problem) has a specific code. This code is included in every sheet. For the sake of precision, a square code was designed for every material and pathology; in addition a round code identified and expressed a complete set of relative solutions (Fig. 5).

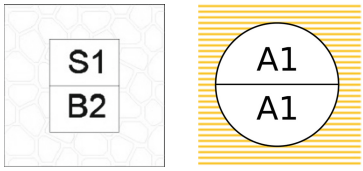


Fig. 5. Code system used for designating pathologies and their respective solutions.

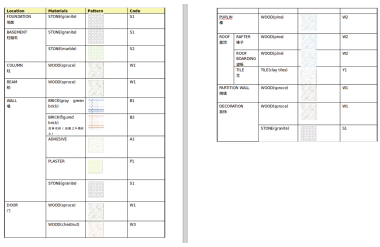


Fig. 6. Complete set of patterns for each material and its type.

Fig. 7. List of logos indicating materials, type, degradation pattern, and level of degradation.

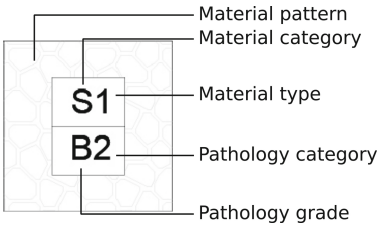


Fig. 8. Description of the information contained in the squared logo.

These two categories are overlapped as a pattern depending on the materials, which seeks to be indicative of the nature of the material. A complete set of patterns was specifically designed for this project (Figs. 6 and 7).

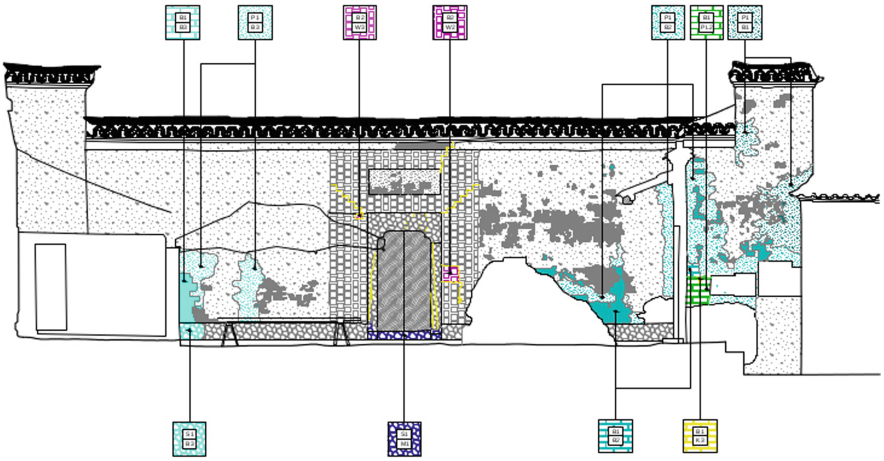


Fig. 9. Complete drawing with the various pathologies in a facade, including the indication symbols for each pathology.

In this specific research related to Yúqìngtáng, the material condition of the building was generally satisfactory. Nevertheless, to be very precise even in this simple case in terms of description and relative solutions on every issue concerning structural collapse and material pathology, it was still mandatory to create a large number of categories.

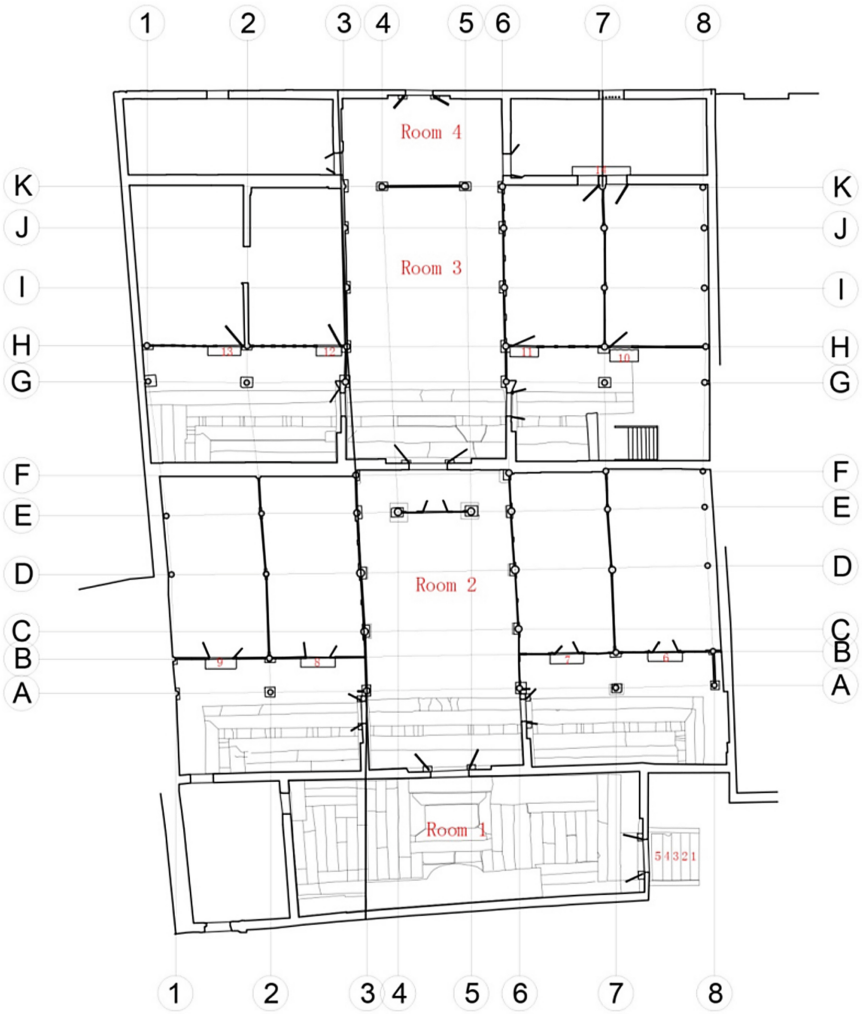


Fig. 10. The column-grid system.

The diagrams of each pathology (Fig. 4) include on the front page the following information:

- name of the diagram;
- name of the building;
- sequential number of the diagram;
- degree of damage;
- logo and category of the problem (squared shape);
- description of the damage condition;
- picture of the problem;
- a synthetic map of the building where the problem is located;

- technical data of the problem;
- reasons for damage.

On the back page we have (Fig. 4):

- solution name;
- logo and category of the problem (round shape),
- how to intervene;
- maintenance strategy.

At the beginning of the research, our team elaborated several categories of intervention. The diagrams were based on:

- categories of intervention;
- material classification;
- diagrams of the pathology;
- mapping of materials.

This was all based on our previous experience in the surveying and intervention of historical buildings, and related to our initial knowledge of the building's condition, including the results of the 3D scanning (facades, sections, plan). The initial strategy was to apply the full method in the real building. But numerous problems were discovered upon commencement of the work, and the initial intention to apply an "Italian method"[7] of renovation was halted for various paramount and interesting reasons that deserve a proper description.

To begin with, the initial material and pathology categories were completely redefined. The preliminary process was incorrect and imprecise. In our opinion the initial logic of the squared logo should be to indicate the material (stone), its type (granite), the pathology (crack) and the grade of the pathology (1 to 3). This initial assumption was incorrect, because the pattern of the material did not precisely indicate the nature of the pathology. Ultimately, redrawing the facade layer presented some incoherences. In fact, the method that we wish to propose was based on the diagrams that we have already illustrated; but these diagrams are directly connected with the AutoCAD drawings (plan, facades, sections and roof plan). These drawings are not only a simple reproduction of the building but also a pattern indication. In this way, the AutoCAD drawings are extremely effective and precise for the state of the degradation of the materials, position and extension for every pattern that could be activated or hidden, and to clarify every specific problem. But this primary intention was misled by our initial pattern, because it only showed the type of the material and not the pathology and the grade of the damage that

[7] In this paper we use two highly generic definitions for our strategy of intervention: the "Italian" and the "Chinese" methods. We are definitely conscious of the fact that this is a large generalization. There is no such thing as a compact and uniform "Italian" method nor any "Chinese" method of restoration. However there are such things as certain established bodies of expertise, specific competences and practices. While this may risk sparking a debate towards which we are quite indifferent, what we wish to emphasize is that these names are employed for the heuristic sake of *simplifying* a general approach which is *more common* in both Italy and China.

was indicated in the “squared logo”. The drawing was monotone and not quite expressive of the complexity of the problems.

After a long discussion, the final solution was a new strategy where:

- the material was indicated by the pattern,
- the material type was indicated by a similar pattern but slightly different in appearance (for example, two different kinds of wood have different patterns but both express a wooden nature),
- the decay of the material was indicated by a color,
- the extent of the decay was indicated by different tones of the same color (Fig. 8).

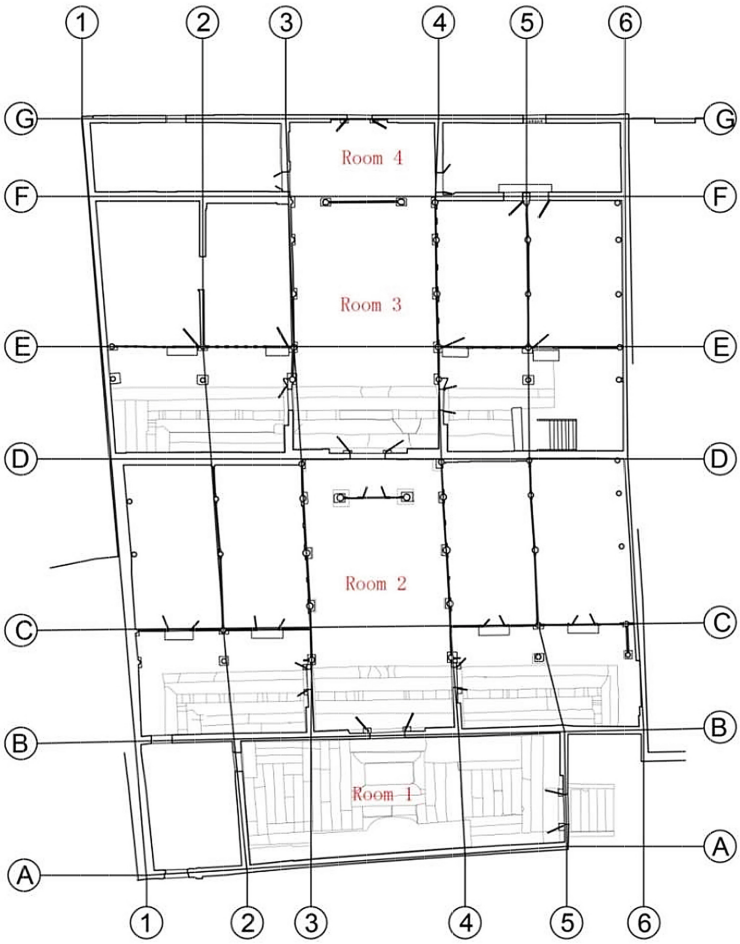
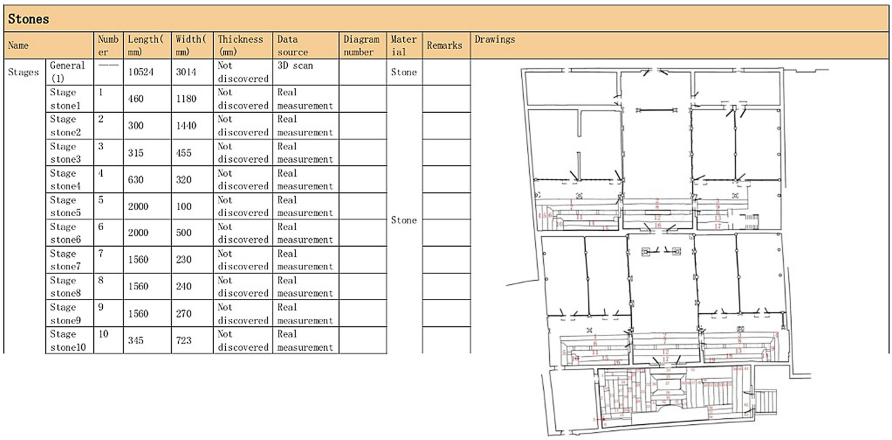


Fig. 11. The wall-grid system.

These four categories were described in the squared logos and also indicated by AutoCAD files in order to create categories mutually dependent on each other (Fig. 9).



Stones

Name		Number	Length(mm)	Width(mm)	Thickness (mm)	Data source	Diagram number	Material	Remarks	Drawings
Stages	General (1)	——	10524	3014	Not discovered	3D scan		Stone		
	Stage stone1	1	460	1180	Not discovered	Real measurement				
	Stage stone2	2	300	1440	Not discovered	Real measurement				
	Stage stone3	3	315	455	Not discovered	Real measurement				
	Stage stone4	4	630	320	Not discovered	Real measurement				
	Stage stone5	5	2000	100	Not discovered	Real measurement				
	Stage stone6	6	2000	500	Not discovered	Real measurement				
	Stage stone7	7	1560	230	Not discovered	Real measurement				
	Stage stone8	8	1560	240	Not discovered	Real measurement				
	Stage stone9	9	1560	270	Not discovered	Real measurement				
	Stage stone10	10	345	723	Not discovered	Real measurement				

Fig. 12. Diagram with the calculation of the quantities of structural elements.

However, this is only a method of adaptation from our primary intention into a practical case, and it is still inside what we can term as an "Italian method". More interesting is the discussion concerning a serious problem that we discovered during the investigation. Our initial method was completely imprecise in terms of the positioning of the architectural elements. The need for precision in terms of structural problems and pathology brought about the necessity to generate a new system for the localization of every single element from its architecture. We found what can confidently be referred to as the "Chinese method" of categorization incredibly useful. According to our experience the practice in the Chinese method of categorization is extremely accurate and is able to precisely indicate every detail of the building.

3 An Innovative Method of Investigation in-Between Italian and Chinese Practices

One of the original achievements of this research, and the innovative contribution of this paper and generally of our diagnosis method and investigation on ancient buildings in China, is the combination of the "Chinese" and "Italian" methods for the restoration of ancient historical buildings. During the work, the progress of the analysis faced a major obstacle: the mandatory categorization and positioning of every single element of Yúqìngtáng. The "Italian method" (definitely within the limits of our study) was unable to precisely illustrate the position of every element of the rich and diverse Chinese traditional architecture. The team, then, pointed out a process that is common in the analysis and investigation of the historical heritage in China. It is a frequently used method among the country's experts, as it is very systematic and accurate. It is based on

an extremely precise system of categorization and quantification of every minute detail of the building.

This system is based on a Cartesian grid (number/letter) that constitutes the coordinates of the main frame of the building. Oftentimes pavilions are built with pillars in Chinese architecture, resulting in a method that has proven to be exceptional in identifying all the architectural details, construction elements and features that are the expression of its philosophy and culture. Every single pillar and wall was identified with a number/letter code. Additionally we must note that in China, ancient architecture was a highly sophisticated art and consequently in their tradition the Chinese already have a very comprehensive and detailed naming system. Our research concerning the history of traditional architecture in China[8] demonstrates that all of its details have a unique feature and meaning.

During the investigation and categorization process, we noticed that even the "Chinese method" has its own weaknesses, and that some processes were not absolutely accurate. This process is unique for its precision and accuracy for framed structures, but we found some limitations for structural systems that include walls *plus* linear structures (wood pillars and beams) when they are not well aligned. This is why our solution was the combination of a *double grid system*:

- **(I)** for the columns (Fig. 10), and

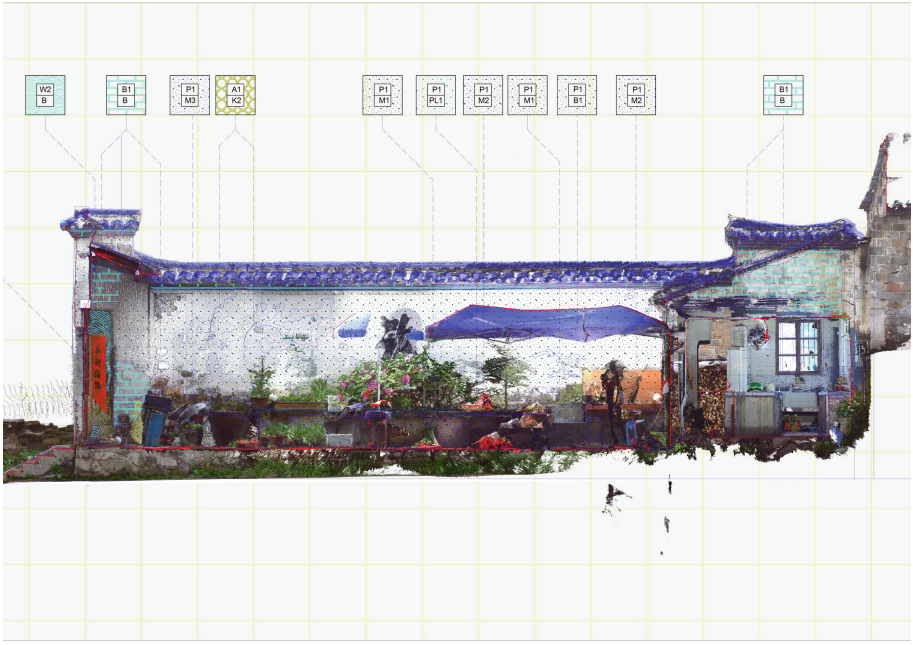


Fig. 13. Picture overlapped on an AutoCAD redrawing of plans, patterns, and pathologies.

[8] Genovese (2017).

- **(II)** for the walls (Fig. 11).

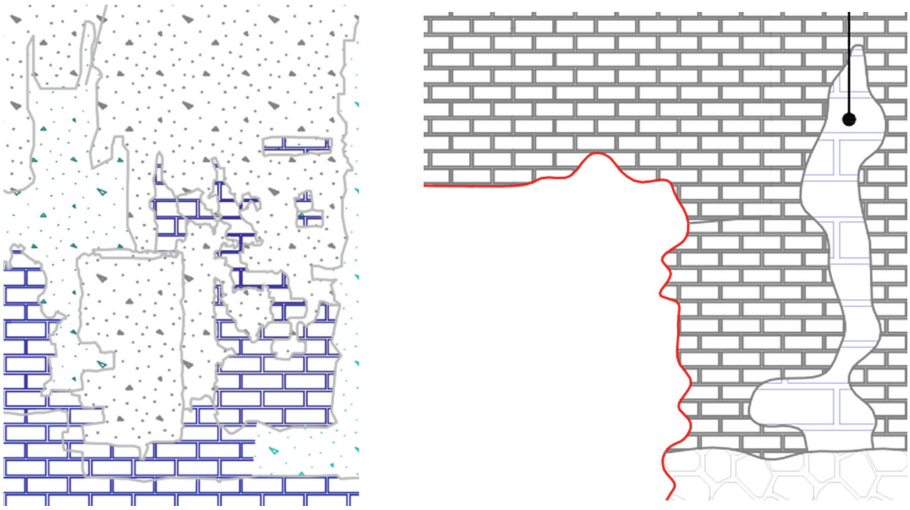


Fig. 14. Comparison between straight line and curved line.

The necessity of the double grid is specifically vital, because each has a different logic and function. As a result of the nature of wood structures in China, (I) was very convenient because every pillar could be characterized by a couple of letters/numbers (G-2, for example) indicating a specific pillar. On the contrary the reason for the case of (II) is because the pathology of a wall could be extensive and it would be necessary to categorize a large portion of the wall in a different way, for example letter/letter/number (A-C-4) or letter/number/number (1-D-F), with the sense that a specific pathology could be extended along the line 1 from crossing D to F.

In further detail, and in order to technically describe our method we have to say that (I) and (II) are two different layers in AutoCAD files; they could be activated case by case, according to the specific architectural element or specific pathology that requires investigation. The combination of the two layers is our original proposal, because in the Chinese practice (at least in our modest knowledge), only a regular frame is usually considered. However, this respectful practice is incompatible with our purposes. In fact the structure of the building could be irregular, deformed by age or perhaps transformed from the initial phase of construction. A regular grid could be noticeably incorrect and consequentially imprecise for the definition, positioning and categorization of the buildings' structural weakness and material problems. Our method on the contrary offers a major advantage. Due to its precision and its specific character of categorization, every single element of the architecture could be numbered and measured, with the consequent possibility to calculate all the quantities and percentages of every part (Fig. 12).

Pertaining to the intervention on Chinese architecture, it is evident that the common Chinese practice for the ancient building's investigation seems to be superior to the

"Italian way"; actually the fact is that it is more complicated and the solution requires an extremely articulated process of thinking. In reality the two methods are quite different, hence we believe that the combination of the two practices could be a radical implementation of the practice regarding ancient buildings in China as well as in other countries. Our intention is to create a general method of analysis and intervention for ancient buildings in general, without being strictly related to a specific country.

During our discussions we noticed that the "Chinese method" as well as the "Italian method" are based on the survey of the real building, pavilion and in general historical heritage; in China, the use of 3D scanning devices is a common practice, and relative measurements are conducted on the real building. On this point the two methods coincide. However, contrary to the "Italian method", in China scholars tend to direct their work towards the recreation of the *ideal state* and *ideal conformation* of the building «as it should be» and not «as it is».

On this point we have to be completely clear: this process is certainly not universal, and in this country we can find countless different approaches, which are extremely professional and very deep in terms of their processes. Nevertheless this seems to be a widespread practice. If we understand the mentality of this complex culture in the area of historical heritage, the direction of the investigation on a given historical building aims to recreate an "ideal" type, without the pathology that necessarily affects an old building, without structural problems, and without the mistakes that the real handicraft necessarily has, when compared with the prototype. In other words, the efforts undertaken during common practice in the field of the restoration are to rebuild a type that could constitute a new model for the future generation. In other words, the old buildings become a new prototype. Following this process, after the investigation, measurement, and restoration phase, the result is not the *real specific building*, but rather that this specific building is taken as a model and as a type.

The "Italian approach" is the complete opposite. It is a specific investigation on the material state of a single building considered unique and exclusive. Speculations regarding its type or the recreation of an ideal model exist both in the European context in general and in practice, but it seems to be an operation that is separate to any specific investigation. In the European practice, it is more of a result of the amalgamation of several cases. The final result is a kind of "statistical combination" of many cases all synthesized together to describe the «general form», the «general type», which is absolutely ideal, but not based on any specific building. In the Chinese practice the building is considered and measured in its *real consistence* but re-drawn in its *ideal form.* In a certain sense, we can say that in China, in terms of real case studies, there is a perception that an ideal model has to be preserved in a state of immutability for future generations. The building appears as an idealized model and we believe that this is an interesting feature of the specific culture of China. The final result in China is a building that appears as new, perfect in its consistence and form. The "Italian model" is the opposite, because it does not try to abstract any form, type or idealistic structure of the building (either art or color) within the specific physical building. There are remarkable speculations on the type and ideal structures on this issue from essay books that are important milestones of the western thinking. But this is more of a philosophical discussion and does not refer

to a single building, nor does it concern the description of the state of the building in a specific moment of its history.

Perhaps one reason for this vast difference relates to the concept of time itself. In the Italian vision, history is confined to the past. The recreation or the actualization of the technique of construction, or materials, or the general sense of the building, could not appear into the modernity because the two ages, ancient and modern, are irreconcilable. The "Italian method", in fact, is simply different to the previous one. It primarily focuses on the categorization of the problem, because the main goal is the preservation of the physical state of the building. The attention is to understand the pathologies, the structural problems, physical destruction of the building, how the structure works, the consistency and the nature of the materials. The intention is to know every single detail of the original status, the quality of the woods, plasters, bricks, mortar, their chemical composition, and so on. All efforts are directed towards understanding the *reality* of the building in its physical detail.

In our opinion, the main intentions point to three major directions:

- **(A)** the understanding of the problems of the building and all the pathologies;
- **(B)** the reasons or causes of (A);
- **(C)** the possible solution, to avoid further physical deterioration.

We believe that the main reason for this process is a specific goal: intervention for the preservation of the originality of the building not in its ideal state, like in the Chinese perspective, but in its specific originality, uniqueness and impossibility of being replaced. The European perspective in general is to give the maximum dignity to a specific building because this case is unique and for this reason a treasure that must remain eternally preserved. The preservation of the building—and similar discussions could be held for art, handicraft or everything which is a legacy from the past—is a necessity at the border of veneration, hence a very sophisticated technique (and relatively important financial investment) must be employed to maintain the original status.

It is indubitable that the "Italian way" is more expensive and difficult, slow and complicated, but the point is that this effort is directed not only to preserve the physical consistency of a specific building but the historical identity contained by a specific building. The "Italian method" is certainly meticulous and perhaps pedantic in the analysis of the physical state. Every single material must be categorized. Every single problem must be understood and described and finally solved. Nevertheless, this perspective that we confidently coined as the "Italian method" has a major weakness: it freezes the past into a sort of ideal state, that is, in the context of a progressive "museification" of the past (or better, a mummification of history).

Our team spent a lengthy amount of time in understanding the reasons for these problems. At the beginning it was very interesting to observe the reaction of some students regarding the solution for a certain specific degradation: «easy, throw it down and rebuild it!». This is not ignorance or superficiality, but a precise philosophical position and practice where the direction is the recreation of an ideal model where the appearance must adhere to the prototype and where the real building is only a contingent case.

All the problems of the building were precisely described into the diagrams that were previously mentioned at the beginning of this paper. However, a very important

and specific question was raised during the work, which we will delve deeper into in the following section: the redrawing of the building.

4 The Redrawing of the Existing Building

Evidently this issue is mechanical and does not contain any specific problems. However, during our investigation, this became one of the major disputes, both from the technical and philosophical points of view. This matter is especially connected with the "Italian method" of investigation. Since this process concerns the description of the reality of the building in its conformation at the present historical moment, a problem arose: how to illustrate by drawing the material consistency of the building?

In the "Chinese method" all the forms and details are somehow idealized, and recreated according to a type. The problem of illustrating "the accurate reality" does not exist, because the redrawing belongs to a totally different approach, the "European method". This method intends to provide as precise a description as possible of the real physical state of the building, here and now, therefore begging the question; what is the level of depth of this "reality"? The practical problem is that it became necessary to redraw all the details, façade, and plans of the building from the 3D scan and the photography. The challenge was to recreate a precise state of all pathologies (for example the area of the wall affected by rainwater, fungus, cracks, etc.) (Fig. 13).

Though difficult and boring, it was a task that proved to be feasible. The most important question was related to the software used for drawing: AutoCAD or similar. It is a common practice in the redrawing of ancient buildings to trace the picture (or the 3D scan image). This means that from the picture one must follow the forms and boundaries of the building on the photography, retracing the existing forms. In previous practices this issue was not so problematic because the imperfections of the real building could be easily covered by the tremble of the human hand while drawing. It was mostly an artwork. But CAD software programs do not allow for this imperfection because they are highly precise, which implies that the result is unreal. During our workshop we found out that some students used the straight-line function but others used the curved line function. The results vastly differed (Fig. 14).

But who was correct? The answer is, nobody was. The main point is that evidently the straight line was better, because it closely follows the shape of the pictures, however, this kind of line is non-existent in nature. Nevertheless, the curved line seems to be more appropriate for certain details. For example: in the case of a squared stone, a basement or similar, the straight line seems to be appropriate, because it follows the initial *intention* of the artisan. However, because of the precision of the picture and the 3D scan, that specific detail reveals a much more complex geometry, which strays further from a straight line or a pure geometry. At the same time, identical problems were found out with the use of the curves. The curved-line function, which was apparently closer to reality, does not actually exist either, and the *final* CAD drawing seems too "organic", too "naturalistic", to belong to architecture. A problem of feeling or *Gestalt psychology*? The question it raises is rather significant, but we are conscious that the answer to this complex question is even more complex: a possible solution is the use of Fractal geometry.

Our choice, far from being a solution to the question, was the combination between the two lines. At times the straight line seemed more appropriate, and at other times

the curve was more precise and adherent to the reality. We remind the reader that this question was not only theoretical but also mostly practical, because the intention of the "Italian method" may be idealistic in the representation of the reality in its consistency. And then, consequently, the problem of the representation of this "reality" becomes fundamental.

5 Our Results

The results of this specific investigation can be divided into three different categories:

- **(A)** specific materials produced in the workshop on the Yúqìngtáng building;
- **(B)** integrated methodology for the survey of historical buildings;
- **(C)** open questions, problems and possible solutions.

Concerning point (A), the team produced the following materials:

1. a 3D scan of the whole building of Yúqìngtáng, with some limitations concerning "obscured areas" not reachable by the laser; from the 3D scan a TIFF image of the plan was produced, three facades (North, South, West)[9], sixteen internal sections and facades, as well as an intrados plan of the roof;
2. a complete record by camera of the whole building, in order to complete the parts missed by the 3D scanner and to create more detailed information for the redrawing phase;
3. redrawing by AutoCAD of all the previous items in points 2 and 3. Three internal facades remain incomplete;
4. a multi-layer grid of coordinates for the categorization of every element in the plan of the building, following the "Chinese methodology" of classification. This set converges in point 10 of this list;
5. a complete and precise AutoCAD file for the plan of the building, including all the pathologies, cracks and problems of the floors, and a complete description of all the materials;
6. a complete and precise AutoCAD file for the intrados roof-plan of the building, including all the pathologies, cracks and problems of the floors, and a complete description of all the materials;
7. a complete and precise AutoCAD file for three facades of the building, including all the pathologies, cracks and problems of the floors, and a complete description of all the materials;
8. a complete and precise AutoCAD file for seven internal sections and facades of the building, including all the pathologies, cracks and problems of the floors, and a complete description of all the materials. Six of them are still pending;
9. a precise statistical diagram illustrating the different elements of the building and their relative measures and quantities;

[9] The East facade proved impossible to generate, because other houses and a series of buildings were attached.

10. a complete set of codes showing the types of materials, pathologies, and levels of degradation;
11. eighteen detailed and comprehensive sketches of cracks and collapsing elements;
12. precise diagrams with a list of all the materials and relative patterns;
13. a diagram with all of the possible reasons for damage in this specific building;
14. nineteen diagrams with all of the pathologies of the building and the materials. The possible solutions for these pathologies related to the materials are still pending.

Regarding point (B), we aim to hold a lengthy debate in our team concerning the degree of coordination between the "Chinese" and "Italian" methodologies, by creating a preliminary theory and method for future investigations on historical settlements. This method has the advantages of being very flexible and feasible at both the building scale and larger scales (village, road system, etc.) and in fact it was applied in several other cases, also illustrated in papers and a book that we have authored. Part of this theory is included in this paper and more materials will be produced in the future. Point (C) will be illustrated in the following paragraph.

6 Open Questions

For some questions that are still pending, the reasons for their unresolved status are as follows: the brevity of our workshop and our relatively recent experience in employing this new combined methodology, the complexity of the problem both in terms of philosophical speculation and technique, and practical matters related to the Chinese context. In short, the questions are:

1. which is the most appropriate drawing technique in this field? (such as straight line, curved line, etc.);
2. which software could be suitable for redrawing the 3D scans and the picture? (We suppose that a touch screen device plus "smart pen" or "smart pen tablet" connected with appropriate CAD software could be suitable for having a more "naturalistic" trace of the line, because as in the past, these lines are created by hand-drawing);
3. what is the "limit of the precision"? (we assume the scale of 1 cm, but in rare cases the scale should go as far as 1 mm);
4. is it possible to use fractal geometry for the solution of problem 1? How may one use fractal geometry in a practical manner in this field?
5. which software is more appropriate for managing this investigation? (We assume that Autodesk Revit could be a good solution);
6. a radical technical problem is related to the results generated by the 3D scan machine. The final result of the scanning process and data processing by the combined software packages of *Scene*, *Cyclone* and *Geomagic* is a cloud point. The file is incredibly large and it can only be managed part by part. The fundamental question in this sense is: Is there a method that could directly transform the "cloud point" (complete or partial) into a 3D computer object? In other words, can the "cloud point" be imported into 3D software like 3D Max, Rhinoceros, Vectorworks, or Revit directly? In this way is it possible to accurately recreate the 3D structure of the building? In our experiment,

this was completely unsuccessful. We have partial results importing a very limited portion of the building into Rhinoceros, but the results were futile because they were full of stretching points, with extremely rough and incomplete surfaces.
7. the "Italian method" of investigation implies the conservation of the building in its originality. This method of preservation is definitely very expensive. Who should finance it? What is the best financial strategy for it?
8. another question related to point 7 is the time period for execution of the restoration project. A philological approach has the necessity of a much longer and accurate process of construction. How could it be possibly applied specifically to China, which is normally extremely dynamic and fast?
9. an extremely complex issue is the current Chinese regulation concerning the philological preservation of ancient settlements that should be directed into the conservation of the original state of the building, rather than their rebuilding.

7 Conclusion

This workshop and specifically this paper intend to open questions and propose an amalgamation of the Chinese and Italian practices and theories in the field of investigation and restoration of ancient buildings and settlements. In our opinion and experience, the profound differences between the two methods imply several philological and critical argumentations that due to the constraints of this paper, we will not delve further into. Additionally, it is noteworthy to state that what we simplistically describe as the "Italian" or "Chinese" method is in fact composed of different gradients of adherence to the reality. We have merely introduced some of the main directions of the matter, without any specific analysis not directly belonging to the specific topic of this paper. We simply wish to mention the strong advantages in combining the two views and methodologies in an effort to create a new and more comprehensive system for investigation of ancient buildings.

The "Chinese method" is exceptionally good for its precision of categorization, as a quantitative analysis of the building in its consistency. This process is extremely good and meticulous for categorizing and measuring all of the constructive elements of the architecture. Their position inside the general frame of the building and the articulation of the building can be easily illustrated. This is specifically good if the "Chinese method" is combined with the "Italian method" which is more direct on the preservation and "crystallization" of the material state of the architecture and the artifact's physical state, by imposing an obsessive respect of the materiality of the original building. This investigation and others already conducted in China are not the conclusion of our research. Some results were achieved, but we believe that the most interesting point of this paper and this method is found in the open questions, as they may lead towards finding an accurate method for investigation and restoration of ancient buildings in China and abroad. We intend to enrich the international debate in order to implement our initial hypothesis.

Acknowledgements. We wish to thank Profs. Bai Chengjun 白成军, Zhang Zhiqiang 张志强, Zhang Zhiyong 张志永, and Wang Shuo 王硕for their expertise and work in generating the 3D

model. Likewise, we wish to thank Mr. Zha Shunlei 查顺磊and his family who opened their house, Yúqìngtáng, to our survey. A special thanks goes to Prof. Peter Hasdell, who took part in our workshop, and gave us precious advice and encouragement for our work. A fine job was carried out by Phuong Sopheadary and Chea Chetha during the initial drawing of the diagrams. The members of my team conducting the surveying of the building were: Mr. Kezala Gere, my main assistant, Jiang Jiayao 蒋佳瑶, Zhao Xinyi 赵欣宜, Ouyang Jia 欧阳嘉, Lyu Zhichen 吕志宸, Zhang Youdan 张又丹, Du Da 杜达and Yang Yiting 杨艺婷. We extend a special thanks to Mr. Li Zhixing 李智兴for his excellent work in arranging this workshop.

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