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The particle reconstruction of historical architectural language: A study using the latest renovation design of Casa Batlló as an example

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Abstract: Historical buildings inherit the significance of specific time in history, architectural language, cultural development, design thought evolution and so on. The reconstruction and design of historical buildings is one of the important ways of urban renewal. On the basis of continuing the heritage of historical buildings, it is an important consideration for the adaptive transformation of historical buildings to carry out minimal intervention and innovative transformation in line with contemporary aesthetics with new technology and modern technology. The application of particle concept to architectural design has a precedent, but it is the first time to apply it to the renovation of historic buildings. This paper takes Kengo Kuma's latest renovation of Casa Batlló as an example, and analyzes from the perspective of particle concept reconstruction. From naturalism to particle, combination of virtuality and reality, sublimation of light and shadow and other aspects, the design concept and effect analysis of particle design techniques are studied. The research results are related to the current global urban renewal, historic building protection and renewal needs. It can provide reference for the inheritance and adaptability of architectural language in the renovation design of historical buildings, and help urban renewal and high-quality development.

Keywords: Historical building; Renovation design; Casa Batlló; The particle

1. Introduction

"There is not a single important human thought that has not been written on stone by architectural art." -- Victor Hugo.

Historical buildings have been carrying art and culture for years. With the change of times and urban renewal, they are faced with repair, protection and renovation design. As can be seen from the existing transformation design of historical buildings, designers have tried a lot of design techniques

to avoid the destruction of the cultural inheritance and value of the original historical buildings after the update, and at the same time meet the aesthetic appreciation of contemporary people, such as: using the same material, similar colors, old and new design elements echoing, Etc. In the process of transformation, with the participation of designers in different times, the architectural spatial characteristics and place spirit also gradually tend to be diversified. The interior space of the building is the most abundant interpretation of the design concept, expression technique and emotional interaction of designers in the past.This paper takes the latest reconstruction project of Casa Batlló, a world cultural heritage building, as an example, proposes a new reconstruction design method of historic buildings, and discusses the continuation and renewal of history and culture from the perspective of particle reconstruction.

1.1 Project background

Casa Batlló is located on Passeig de Gracia in the center of Barcelona, Spain. The original design displeased the owner of the household, Josep Batlló, a Barcelona textile magnate, who wanted his home to be different and superior to his neighbors (Enlun 2013). In 1904, Antonio Gaudí was invited to carry out the first renovation of Casa Batlló with the "Art Packaging Law", and the remodeled building was full of mystery and far exceeded the expectations of the owner. This project won Gaudí the Barcelona Award for Best Architecture in 1907 and was listed as a UNESCO World Heritage Site in 2005.

After a century of vicissitudes, Casa Batlló has been undergoing conservation work to maintain its condition after Gaudí's transformation. That is, until The current owners, The Bernat family, invited architect Kengo Kuma in 2015 to give the interior a partial makeover.[1] Gary Gautier, CEO responsible for the design of this renovation, said: "The only constant in life is the change itself, if we don't want to be obsolete by this era, we need to adapt to this era, what can we do to make our museum the most interesting place in the city? How can we get people excited -not just some, but everyone (Coulleri 2021)? " At this point, Gaudí's classic work -- the world cultural heritage building -- Casa Batlló has injected new vitality of diversified forms.

1.2 The Particle design concept

The particle is the smallest component of matter that can exist in a free state. It is not the actual existence of specific substances like neutrons and protons, but their collective, is a model idea (Kirkland 2011). The concept of pure particles is a concept that tends to be physics and chemistry, but architectural particles are not, it is the decomposition and overlap of modules that tend to the visual field. Building particles are a concept of scale, an orderly repetitive combination that turns a large scale of a material element into a small scale.

Kengo Kuma, a Japanese architect who proposed the concept of architectural particles (Kuma 2010), said: "People often judge the size, distance, biology, and status of a space through particles one by one in the space, and when people see these particles, they feel very relieved(Lixiao 2012)", "My intention is not to create architectural works that resemble particles, but to create a fuzzy form like a fluttering particle. The closest thing to this pattern is the rainbow (Belogorovsky 2009)". Kengo Kuma's architectural ideas are deeply influenced by traditional Japanese culture, and he is good at reusing a lot of small components in his designs, purposefully creating new sequence combinations.

[1] The latest renovation of Casa Batlló includes the addition of two floors to the entire building,New spiral staircase (completed by Chesneys Architectural, a specialist stone engineering team in the UK)and metal mesh wall decorations and partitions designed by Kengo Kuma.

The concept of architectural granularization is to create a hazy symbiosis between the building and the environment. The repetition of unit elements connects the indoor and outdoor environments, maintains the continuity of space, in addition to vision, immerses more senses such as touch and smell into the architectural atmosphere, making the building itself a medium between man and nature, materials, building interior, and place home, extending the ecology and integrity of the environment.

1.3 Existing research

At present, there is no literature research on the latest renovation design of Casa Batlló. Only online articles and tourism websites have editors to introduce the effects of the renovation for publicity and promotion. Some famous online platforms such as Zhihu, Sohu, ART AND DESIGN, Thepaper.cn, BiliBili and Casa Batlló's official website reported the two renovation designs of Casa Batlló, mainly introducing the pictures after the second renovation of Casa Batlló to attract tourists from all over the world.

At present, according to the analysis of the materials that have been mastered, the research achievements of particles in various fields are very considerable, but the research of "building particles" is still shallow, and the research fields are concentrated in architecture, chemical engineering and technology, physics, computer science and technology (Table 1). The main research topics are antipyretic particles, particle injection technology, nanoparticles, particle models, and particle swarm, which tend to be in the direction of physics and chemistry. Kengo Kuma's book "The Architecture of Nature" describes the theory of "particle architecture", which is inspired by the association of color dots in Georges Seurat's painting "Le Bec du Hoc, Grandcamp" (1885)[2], and by the German philosopher G.W. Leibniz's Monad Theory further determined the "Particle" theory and applied it to architectural design[3].

In Zhang Tian's study "The Creation of Virtuality and Reality -- Interpreting the' Gap Space 'in Kengo Kuma's Architecture", "gap space"refers to the gap space when architectural particles overlap. Zang Qian's New Idea of "Making Architecture Disappear" analyzes the construction way of "particle architecture". Hong Curen's "From'Fragmentation' to 'Particle' "explores the direction of" hidden construction ". Liu Ying and Fan Guifang's "The Indisputable Relationship of Architecture" uses the Stone Art Museum as an example to study how "particle architecture" can achieve the integration of architecture and environment.

What role does the concept of particle play in the reconstruction of historical buildings? How to incorporate contemporary design techniques, materials and aesthetics into historic buildings?

The research results of this paper fill the research gap, and discuss the value and application of the concept of particle in the reconstruction of historical buildings from the perspective of philosophy, in order to respect and continue the historical culture and update historical buildings in line with the contemporary aesthetic to do the greatest protection and innovation. The research results are related to the current global urban renewal, preservation and renewal of historical buildings, which is an important design method to protect historical and cultural inheritance and sustainable development of architectural renewal.

[2] Georges Seurat (1859 -- 1891) was a French painter and founder of the New Impressionist school (Pointillist). He has received a complete fine arts education, and has done a lot of experiments on optics and color theory. He created not many works in his life, but his theory and techniques on later artists can not be ignored.

[3] Got-tfried Wilhelm Leibniz (1646 -- 1716) was a German philosopher, mathematician and scientist. His major works include Talks on Metaphysics, A New Theory of Human Reason, A Treatise on the Divine, and Monad. He regarded the monad as an active and indivisible mental entity, the foundation and final unit of things.

Table 1. Literature data analysis for "particles" and "building particles"[4].Source: Made by the author.

	Keyword: particle		Keyword: Architecture particle	
	Domestic literature	International literature	Domestic literature	International literature
Data	37,000(2021); 18,000(2022); 1,043(2023);	105,000(2021); 33,000(2022); 2357(2023);	364(2021)； 175(2022)； 9(2023)；	404(2021)； 144(2022)； 12(2023)；
Field	Physics, Chemistry, Chemical Engineering and Technology	Physics, Materials Science and Engineering, Chemistry	Architecture, Chemical Engineering and Technology	Physics, Computer Science and Technology

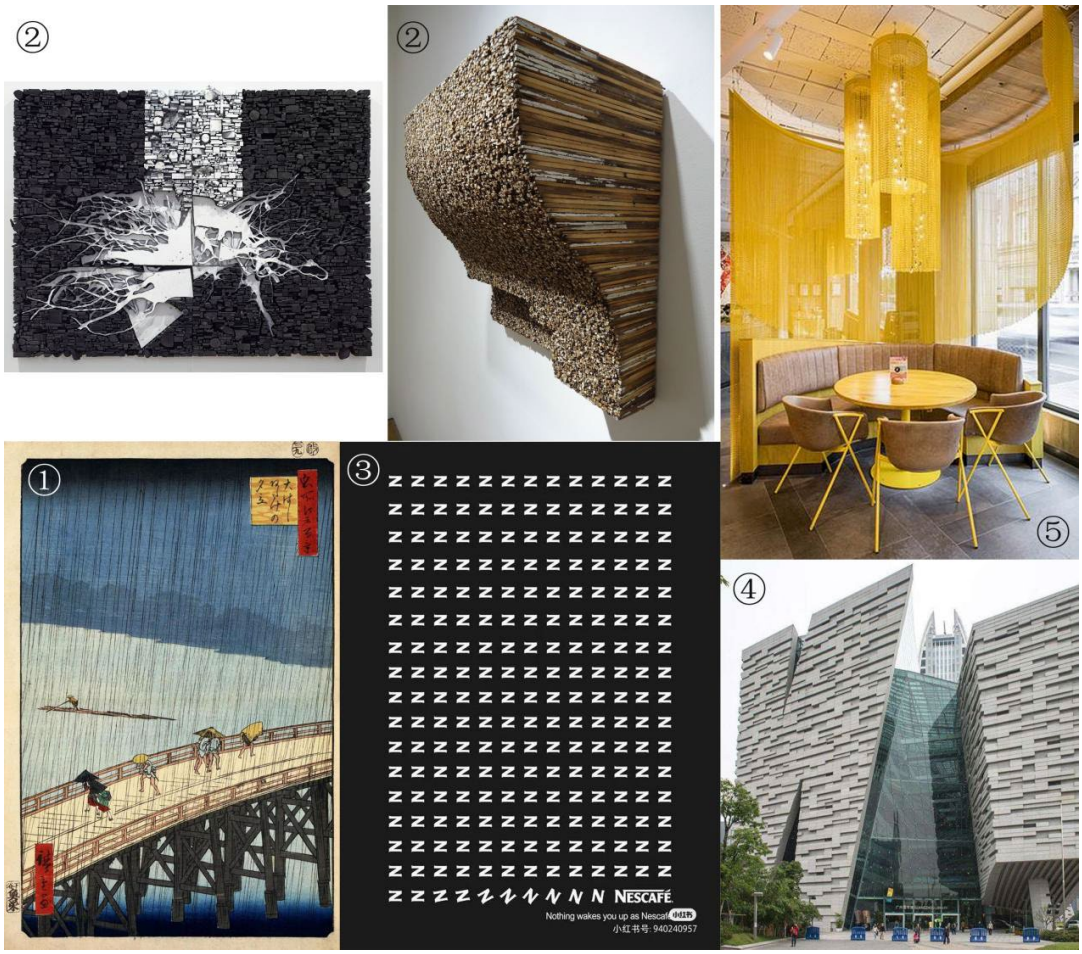

Figure 1. Hiroshige Ando's work "Sudden Rain in Ohashi Ataka"; Figure 2. Leonardo Drew's sculpture "No. 197"; Figure 3. Nescafé Poster; Figure 4. New Library of Guangzhou, China; Figure 5. Nando's Altrincham.Source: Zhihu(Figure 1-4), Kriskadecor's website(Figure 5)

[4] The data comes from Baidu Academic.

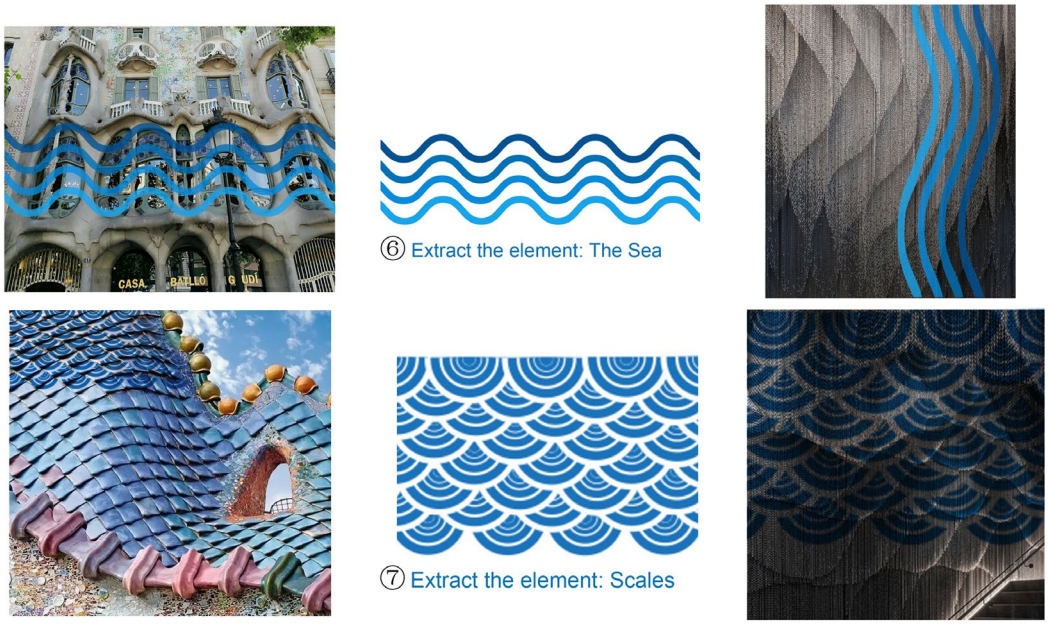

Figure 6. Abstract transformation of sea elements; Figure 7. Abstract transformation of scale elements.Source: Made by the author

Table 2. Application cases and advantages of particles in the field of art. Source: Made by the author

Category	**Cases of duplicate elements**	**Advantages**
Painting	Hiroshige Ando's "Sudden Rain in Ohashi Ataka" (Figure 1)	The overlapping diagonal lines express the movement of rain falling, deepening the layering of the picture.
Sculpture	Leonardo Drew's sculpture No. 197 (Figure 2)	The stacked and layered sculptures activate the space they occupy with a dynamic presence, where complexity and simplicity coexist. Abstract landscapes that rise and shrink through a combination of natural and man-made shapes.
Graphic design	Nescafé Poster (Figure 3)	The overlap of elements creates a regular rhythm in the visual effect, and the change of elements is the finishing touch.
Building	Building façade of the new Guangzhou Library, China (Figure 4)	The repetition of building materials or modular elements divides the thickness of the building into lightweight gaps, allowing the interior and exterior of the building to communicate with the natural environment.
Interior decoration	Interior decoration of Nando's Altrincham (Figure 5)	The unit metal chain links are combined into a metal mesh chain, which softly and flexibly divides the space and plays the role of the partition wall, while the translucent visual effect changes the visual shortcomings of the traditional partition wall that obstructs the line of sight and reduces the space area, making the space transparent and mysterious.

2. Method

Firstly, the literature research method. The documents currently available are the documents of the first renovation design of Casa Batlló, and the documentation materials of the second renovation

design are blank. Organize the literature of Gaudí's design concept and the first renovation design of Casa Batlló, as well as the "particle" and "architectural particle" design concept.

Secondly, the case study method. Horizontal analysis of particle application cases in various fields of art (Table 2). Examples of architectural studies include the new Library in Guangzhou, China (Design by Guangzhou Design Institute); Sulwhasoo's first flagship store in Seoul, South Korea (Design by RuEn Design Lab); Bamboo House, a commune at the foot of the Great Wall of China (Design by Kengo Kuma); and the Folk Art Museum of the China Academy of Art (Design by Kengo Kuma), etc. Although these are not historical buildings, but the design approach is related to the concept of particle, these architectural works to provide a detailed basis and reference for the study of the latest renovation design of Batlló House. The characteristics and advantages of historical building reconstruction design under the concept of particle are further analyzed.

Thirdly, the image analysis method. The elements, shapes, design techniques and architectural language of the two reconstruction designs were analyzed, and conversion elements were extracted (Figure 6 and 7) to analyze the respect and continuation of the particle design for historical buildings in terms of element conversion, materials, light and shadow.

Fourthly, the comparative art research method. To compare the two renovation designs with images, tables and data, highlight the study of the abstract expression of particle technique under the requirements of contemporary aesthetics and technology, free from the restrictions of history, materials and cultural background, and the inclusiveness of historical buildings and architectural transformation.

3. The particle reconstruction of Casa Batlló

Austrian artist Alois Riegl once said that a historical and cultural building mainly carries two values, one is historical value and the other part is contemporary value. The basic principle of the restoration of historical buildings is to maintain the authenticity of the building, but the renewal of the building not only considers the continuation of historical information and value, but also considers its contemporary value.

Therefore, the renovation design of historical buildings should follow the principle of continuity, minimum intervention, recognizability and reversibility.

- Protect the original structural system as much as possible, pay attention to the relationship between structural reinforcement and the original structural form and structural system, strengthen the integrity, improve the force condition of the components, and improve the comprehensive seismic resistance;
- Meet the use requirements of the owner, ensure the safety of the structure under the use of loads, the strength checking calculation of the structural components under the use of loads meet the current norms, strengthen the insufficient strength of the components, and leave room for appropriate;
- The layout of reinforcement or new components should eliminate or reduce unfavorable factors, prevent local strengthening from causing sudden changes in structural stiffness or strength, minimize damage to the original structure, and retain structural components with use value, try to use the bearing capacity of the original structure, and avoid unnecessary demolition or replacement;
- The decoration is mainly lightweight to ensure that the design is safe and reliable.

The historical building after renovation and design can meet the needs of urban renewal and functional renewal, and at the same time change the characteristic structural system of the original historical building with minimal extent.

The architectural background of the second renovation of Casa Batlló is after Gaudí's renovation design, which has been regarded as a classic world cultural heritage. The distinctive naturalistic imitation design covers the whole building and extracts the elements of nature from the whole to the details. In front of such an impeccable building with distinct personality, it is not easy to transform it.

3.1 The particle of naturalistic elements

The application of particles in the field of art is not limited to the exploration of architectural design, but also has application cases in painting, sculpture, graphic design, interior decoration and other aspects (Table 2), which is manifested as the repetition of elements. Presents a vivid and impressive visual effect.

In the conception of the second renovation of Casa Batlló, the designer used modern design techniques to abstract naturalism, cleverly extracting the two main elements of the sea (Figure 6) and the scales (Figure 7) from many elements to carry out a particle design of abstract transformation.

Kengo Kuma is deeply influenced by Japanese traditional culture, and his works not only use particle design techniques, but also focus on cultural expression. The multiple visual effects of the space are reflected in the unique facade rhythm formed by the combination of metal mesh chains in the shape of scales. It was also inspired by the work "Sudden Rain in Ohashi Ataka" (Figure 1) by the famous Japanese Ukiyo-art painter Ando Hiroshige[5].Ando Hiroshige's works are characterized by multiple levels of space. In his painting space, multiple Spaces with thin depth are layered on top of each other. Kengo Kuma once said: "Hirogru uses vertical lines to depict the rain, thereby reflecting the multipleness of the space (Kuma 2005)." In this interior space, he uses overlapping metal vertical lines to express the multiplicity of the historical space.In the renovation of Casa Batlló, the overlapping metal mesh chains designed by Kengo Kuma show a multi-spatial effect across time and space. Multi-layering is the theme that runs through the details, just like Ando Hiroshige's painting space, which is composed of the accumulation of many layers with shallow depths.The metal mesh chain device uses the shape of the waves and scales to "dip" the meaning of the building layer after layer into the interior of the building, static but with a dynamic light flow, as visitors move in it, they can experience the spiritual state from the initial feeling of the rhythm of the building to the gradual return to nature.

3.2 The particleization of materials

Gaudí regards architecture as sculpture, which is elaborately carved from the whole to the details, and uses rich and diverse materials. Visual effects are mainly "solid" and "thick". If the reconstruction on this basis is combined with heavy design, it will be like gilding the lily.

[5] Ando Hiroshige, a famous Japanese ukiyo-art painter in the 19th century, was an outstanding master of color woodcuts. His painting style is characterized by rich picture layers, profound space and emphasis on lines (especially vertical), which had a great influence on European Impressionism. Ando Hiroshige's engraving "Sudden Rain in Ohashi Ataka" is extremely expressive and is famous for being copied by the Dutch post-Impressionist master Vincent Willem van Gogh.

Lao Tzu's Tao Te Ching says:“There is nothing weaker than water, and no matter how tough things are, they cannot defeat water. Weak is better than strong, soft is better than rigid, no one in the world does not know, but no one can do it.”[6]

Kengo Kuma knows this well. He used the "virtuality" and "lightness" of particles, he extracted one of the many materials used by Gaudí - metal, and customized it with modern technology, so that the metal mesh design of the transition space is full of lightness and transparency. Grasp the meaning of the building as a whole, so that the newly built transitional space is integrated into the historical building, and the connection between the old and the new is completed without losing innovation. Parallax is formed with virtual penetration, so that the newly renovated part and the original building form a complementary and contrasting relationship (Table 3).

The scale of the particles is precisely controlled, and Kengo Kuma's size ratio system comes from his material treatment, the design method varies from material to material, the details and structural system also change from material to material, and the size of material parts must be adjusted according to the structural system and construction technology. At the same time, the scale of material particles should also consider the coordination between the building and the surrounding environment to form an overall size ratio system (Yu, Hongbin 2010). The "gap" in the form increases the interaction between the building and the environment, creating a vague, ambiguous, and flexible architectural form, thereby weakening the barrier between the building and the environment and reducing the pressure caused by the building (Figures 8, 9, 10).

"I want the architecture to go away. I've been thinking about this for a long time, and I'm not going to change my mind, "he said in an interview with Urban Environmental Design magazine, famously stating that" materials make buildings invisible (Kuma 2003)."

Kengo Kuma's design allows architecture and the spatial environment to coexist peacefully, combining the virtual and the real, often constituting simple, direct, and effects that do not destroy or exceed the existing environment or parts of the existing building. Its architectural ideal aspires to reach a state of "intangibility", to create "objects that cannot be fixed into tangibles".

Table 3. Material comparison of two renovations of Casa Batlló. Source: Made by the author

Designer	Material	Peculiarity
Gaudí	Stone, wood, stained glass, fragments of stained ceramics, metal, lime...	Figurative, strong
Kengo Kuma	Metal	Abstract, weak

3.3 The particle of light and shadow

The metal mesh chain is designed to be layered on top of each other, and different shades of aluminum are organized so that the light passing through the building is filtered into particles, starting from the bright roof and gradually becoming dark, until the deep coal cellar becomes black before reaching the basement, realizing the multi-layered building. Through this light gradient reminiscent of the use of patio color, the mysterious story of the building is told by the change of light and shadow. From the roof to the basement, everything is displayed by light only, integrating human, nature and architectural space into the artistic conception.

[6] Lao Tzu, formerly known as Li Er, a native of the late Spring and Autumn period, Lao Tzu thought had a profound impact on the development of Chinese philosophy, and the core of his thought was simple dialectics. He is the author of the legendary work "Tao Te Ching".

In his architectural statement, Kuma said: "Gaudí's transformation of Casa Batlló is a tribute to the light of the Mediterranean, especially its light, shadow and the colors of the sky and sea. The central courtyard captures the light of the Mediterranean Sea and distributes it vertically to all corners of the house. The color gradient from dark blue to light blue adds light to its vertical march and ensures that it does not lose pigment. In our project, we want to talk about the genius use of light[7]; Make sure that every visitor leaving Casa Batlló appreciates this quality, independent of admiration for the building's incredible shape, craftsmanship and symbolism. We wanted to do it in an abstract way. Through this abstraction, getting rid of the color, material and historical dimensions of the house, we talk about the concept of light without distraction and nostalgia (Figures 11). " □Coulleri 2021)

4. Conclusion

Historical buildings themselves not only express the architectural form, but also bear the historical memory, the changes of The Times, aesthetic changes, construction level, material characteristics, multiple design concepts. The new and old buildings need to achieve a certain degree of unity in all aspects and the contrast after innovation.

The latest renovation design of Casa Batlló is another fresh injection after Gaudí's immortal classic design, Kuma Kengo uses Building particle design techniques, on the basis of inheriting the architectural theme style, using the repeated combination of metal mesh chain materials to shape the shape, filtering the light layer by layer, penetrating into the space, completing the artistic conception sublimation between man and nature, and the architectural space environment. It not only shows the designer's superb design techniques and grasp of material characteristics, but also reflects the inclusiveness of contemporary architectural design, and emphasizes the importance of the interrelationship between man, nature and architecture, as well as the innovative combination of traditional culture and modern technology contained in the design concept. As Chinese architect Ieoh Ming Pei[8] once said: "New technologies and new materials are important, but in architectural creation, it is more important to find your own national path, so that the building has a unique national style and form." The particle architectural design method is not only applicable to the maintenance and transformation of historical buildings, but also can be applied to other architectural designs, such as Liyuan Library designed by Li Xiaodong (China); Kengo Kuma (Japan) bamboo house at the foot of the Great Wall; Ningbo City Exhibition Center (playze, Switzerland, schmidhuber, Germany), etc (Figures 12-14).

At present, with the rapid development of economy, everything is fast and efficient. However, this is very dangerous for architectural design. The time left for designers to create is not enough to incubate truly meaningful buildings that contain cultural inheritance, have unique national or regional styles, and attach importance to the harmonious relationship between human and nature. Especially for the restoration and renovation of historic buildings of great significance. Therefore, the two renovation designs of Casa Batlló show the inheritance of historical architectural language, the inclusiveness and innovation of modern design techniques, the design concept of emphasizing the immersive experience of the built environment and the integration of nature, and the particle

[7] The "genius use of light" here refers to the genius design and use of light by the previous designer, Gaudí, in the first renovation of Casa Batlló.

[8] Ieoh Ming Pei, whose ancestral home is Suzhou, Jiangsu, China, is a Chinese-American architect.His works are mainly modernist public buildings, cultural and educational buildings, and he is good at using steel, concrete, glass and stone, and representative works include the expansion of the Louvre in Paris, the Bank of China Tower in Hong Kong, the new Suzhou Museum,and so on.

reconstruction of the deconstruction of architectural boundaries, which is worthy of in-depth study by contemporary architects.

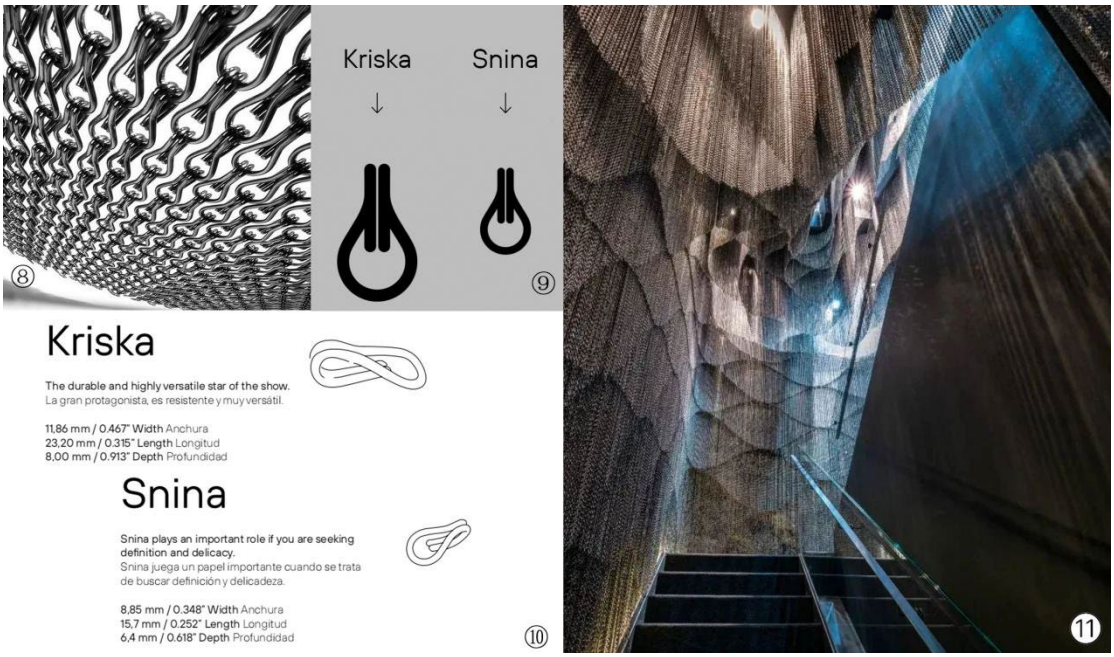

Figure 8. Metal mesh chain details; Figure 9-10. two links of Kriskadecor; Figure 11. Light and shadow effects after the second renovation of Casa Batlló. Source: Kriskadecor website

Figure 12. Liyuan Library; Figure 13.Ningbo City Exhibition Center; Figure 14. bamboo house at the foot of the Great Wall. Source: Baidu.

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